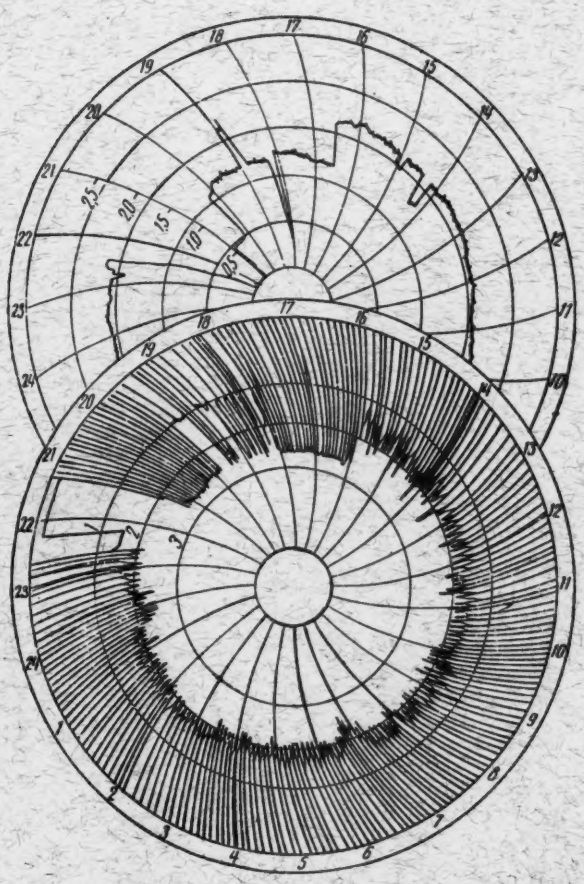
Number 11

November 1958

METALLURGIST

translated from Russian



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Pavel Petrovich Borodin — senior pickling-bath operator at the cold-rolling plant of the A.N. Kuz'min Novosibirsk Metallurgical Works.

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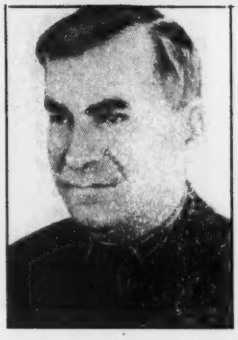
Ivan Nikiforovich Vdovenko— senior mill operator at the steel-rolling mill of the Nizhne-Tagil Metallurgical Combine.

Vasilii Alekseevich Veretenov— steel melter at the open-hearth works of the Vyksa Metallurgical Works.

Vasillii Grigor'evich Vershinin – director of the Seversk Metallurgical Works.



Feodosii Dionis'evich Voronov – director of the Magnitogorsk Metallurgical Combine.

Khafiz Ganiev – senior-foreman assistant at the open-hearth plant of the Lenin Uzbek Metallurgical Works

Konstantin Fomich Garagulia-senior operator at the tube drawing plant of the Nikopol' Tube Works

Aleksei Vasil'evich Giblov – blacksmith at the forging and pressing plant of the Chebarkul' Metallurgical Works.

Petr Arsent'evich Gmyria – director of the Voroshilov Alchevsk Metallurgical Works.

Stepan Illarionovich Goncharuk – senior mill operator at the tube-rolling mill of the Cheliabinsk Tube Works.

Anatolii Prokop'evich Gorbunov – steel melter at the open-hearth plant of the Ashinsk Metallurgical Works.

Vladimir Alekseevich Goriunov – senior mill operator at the plate-rolling mill of the Izhora Works.

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Mikhail Ivanovich Gritsenko – foreman at the blast-furnace plant of the Voroshilov Alchevsk Metallurgical Works.

Grigorii Petrovich Gromakov – senior mill operator at the steel-rolling mill of the Makeevka Metallurgical Works.

Il'ia Makarovich Griazin — foreman at the electric steel-making plant of the Zlatoust Metallurgical Works

Pavel Vasil'evich Griazin — team leader at the electric furnace of the Aktiubinsk Ferroalloy Works.

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Vladimir Nikolaevich Gusarov —director of the Cheliabinsk Ferroalloy Works.

Mikhail Gavrilovich Gusarov —steel melter at the open-hearth furnace plant.

Fedor Aleksandrovich Danilov —director of the Pervoural'sk Tube Works.

Fedor Kuprianovich Dediurin —senior operator at the steel-rolling plant of the Zlatoust Metallurgical Works.

Vitalii Petrovich Deev — senior mill operator at the seamless-tube plant of the Lenin Dnepropetrovsk Tube Works.

Aleksei Lukich Derevianko —foreman at the steel-rolling plant of the Il'ich Zhdanov Metallurgical Works.

Stepan Iaklovlevich Didenko- senior operator at the blooming mill of the Magnitogorsk Metallurgical Combine.

Vladimir Stepanovich Diordiev —director of the Frunze Konstantinovka Metallurgical Works.

Peter Ivanovich Egorov — foreman at the blast-furnace plant of the Petrovskii Works.

Grigorii Andreevich Emel'ianenko — senior operator at the slab-rolling mill of the "Zaporozhstal" Works.

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Boris Nikolaevich Zherebin — director of the Kuznetsk Metallurgical Combine.

Aleksandr Illarionovich Zhukov — director of the Kirov Makeevka Metallurgical Works.

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Iakov Ivanovich Zakoliukin — senior mill operator at the rolling mill of the Revda Hardware Metallurgical Works.

Anatolii Fedorovich Zakharov — director of the Nizhne-Tagil Metallurgical Combine.

Murad Makhmud Ogly Zeinalov — steel melter at the open-hearth plant of the Baku Tube Works.

Gavril Nikiforovich Zolotov — mill operator at the section mill of the "Serp i molot" Metallurgical Works.

Mikhail Petrovich Ivanin —senior operator at the new rolling plant of the Dzerzhinskii Works .

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Aleksei Mikhailovich Inozemtsev — steel melter at the open-hearth plant of the "Azovstal" Works.

Pavel Efimovich Iniutin — senior furnace attendant at the blast-furnace plant of the Kuznetsk Metallurgical Combine.

Viktor Vasil'evich Kanareikin — steel melter at the open-hearth plant of the Dzerzhinskii Works.

Aleksandr Grigoreevich Kartavykh — senior mill operator at the plate-rolling mill of the Kuznetsk Metallurgical Combine.

Leonid Sergeevich Klimasenko — formerly chief steel melter of the Kuznetsk Metallurgical Combine, now deputy chairman of the Kemerovo National

Aleksei Petrovich Kliukin — head of the steel foundry of the Stalingrad Tractor Works.

Vardish Georgievich Koberidze —senior foreman at the blast-furnace plant of the Zakavkaz (Transcaucasus) Metall. Works.

Emel'ian Samsonovich Kozhokaru—senior melter at the Kuznetsk Ferroalloy Works.

Konstantin Matveevich Kononenko —senior foreman at the open-hearth plant of the Kuznetsk Metallurgical Combine

Nikolai Vasil'evich Koniakhin—steel melter at the open-hearth plant of the Kuznetsk Metallurgical Combine.

Il'ia Ivanovich Korolov —director of the Petrovskii Works.

Petr Efimovich Krasil'nikov—furnace attendant at the blast-furnace plant of the Novo-Tula Metallurgical Works.

Iakov Pavlovich Kulikov —head of the Metallurgical Industry Department of the Stalino National Economic Council.

Ivan Stepanovich Kutsenko—senior foreman at the tube-rolling plant of the Nikopol Tube Works.

Sergei Maksimovich Lebedev—senior foreman at the open-hearth plant of the Kirovo Works.

Vladimir Dimitrievich Loskutnikov — steel melter at the Petrovsk-Zabaikalskii Metallurgical Works.

Dmitrii Vasil'evich Lunin — foreman at the blast-furnace plant of the Kirov Makeevka Metallurgical Works.

Ivan Andreevich Lut — senior foreman at the open-hearth plant of the Il'ich Metallurgical Works.

Aleksandr Grigor'evich Lykov —steel melter at the electric and open-hearth plant of the Izhevsk Metallurgical Works.

Ivan Samsonovich Liulenkov —chief mechanic of the Kuznetsk Metallurgical Combine.

Fedor Frolovich Mamichev —senior welder at the rail-structural mill of the Enakievo Metallurgical Works.

Petr Semenovich Makhota — steel melter at the open-hearth furnace of the Petrovskii Works.

Bagrat Sergeevich Melkadze — shift head at the melting plant of the Zestafoni Ferroalloy Works.

Ivan Georgievich Mogilevtsev—senior foreman at the open-hearth plant of the Kuznetsk Metallurgical Combine.

Vasilii Mikhailovich Morozov—head of the blast-furnace plant of the Serov Metallurgical Combine.

Vasilii Leont'evich Murzak—scale-car operator at the blast-furnace plant of the Krivoi Rog Metallurgical Combine.

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Nikolai Konstantinovich Nikonov — senior sinter-machine operator at the Kamysh-Burun Iron-Ore Combine.

Aleksandr Grigor'evich Novikov—charging machine operator at the Zlatoust Metallurgical Works.

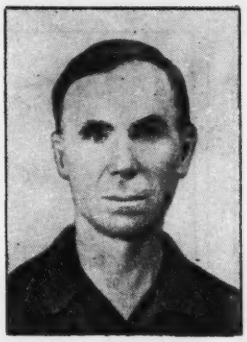
Dmitrii Grigorievich Noskov—foreman at the blast-furnace plant of the Chusovskoe Metallurgical Works.

Anatolii Ivanovich Ol'khovikov— senior foreman at the blast-furnace plant of the Cherepovets Metallurgical Works.

Georgii Grigor'evich Oreshkin—director of the Dzerzhinshii Works.

Nikita Ustinovich Paukov—senior foreman at the rolling mill of the Magnitogorsk Metallurgical Combine.

David Ivanovich Petrov—senior foreman at the rolling mill of the Magnitogorsk Metallurgical Combine.



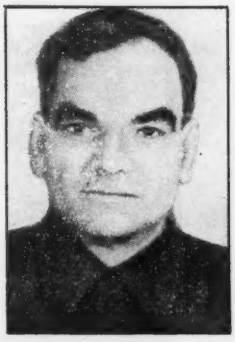
Kuz'ma Andreevich Petrukhin —senior mill operator at the section mill of the Stalino Metallurgical Works.

Fedor Dmitrievich Petukhov — steel melter at the open-hearth plant of the Verkh-Isetsk Metallurgical Works.

Nikolai Gavrilovich Pokutnii —furnace attendant at the blast-furnace plant of the Enakievo Metallurgical Works.

Grigorii Konstantinovich Pometun — steel melter at the open-hearth plant of the "Zaporozhstal" Works.

Mikhail Moiseevich Privalov— senior foreman at the open-hearth plant of the Kuznetsk Metallurgical Combine.



Petr Efimovich Protasov —charging-machine operator at the open-hearth plant of the Magnitogorsk Metallurgical Combine.

Ivan Alekseevich Piatigorskii — senior furnace attendant at the blast-furnace plant of the Cheliabinsk Metallurgical Works.

Savelii Borisovich Rudenok— foreman at the plate-rolling mill of the Novomoskovskii Tinplate Works.

Andrei Konstantinovich Rudkov — head of the sinter plant of the Dzerzhinskii Works.

Aleksei Mikhailovich Rusin—steel melter at the open-hearth plant of the Seversk Metallurgical Works.

Grigorii Iakovlevich Rybalka —senior furnace attendant at the blast-furnace plant of the Almaznaia Metallurgical Works.

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Iakov Evlampievich Riazantsev-senior operator at the rolling plant of the "Dneprospetsstal" Works.

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Ivan Semenovich Sopov—senior mill operator at the cogging mill of the Magnitogorsk Metallurgical Combine.

Nikolai Efremovich Sochnev—senior foreman at the blast-furnace plant of the Novolipetsk Metallurgical Works.

Iakov Grigor'evich Spirin—steel melter at the open-hearth plant of the Cheliabinsk Metallurgical Works.

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Prokofii Mikhailovich Fedotov—foreman at the blast-furnace plant of the Kuibyshev Kramatorka Metallurgical Works.

Vladimir Pavlovich Filatov—director of the Serov Metallurgical Combine.

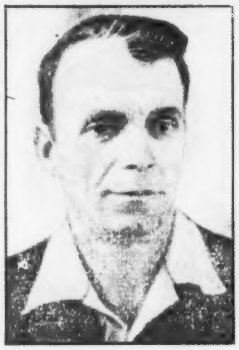
Mikhail Ivanovich Fomin—steel melter at the open-hearth plant of the Voroshilov Alchevsk Metallurgical Works.

Fedor Aleksandrovich Khil'kevich—head of the blast-furnace plant of the Nizhne-Tagil Metallurgical Combine.

Georgii Lukich Khimich—chief designer of the metallurgical equipment at the Ural Works of Heavy Machinery.

Ivan Il'ich Khotenkov—foreman at the steel-rolling plant of the Makeevka Metallurgical Works.

Semen Ivanovich Tsipko—foreman at the blast-furnace plant of the "Zaporozhstal" Works.



Nikolai Ivanovich Chernykh—foreman at the tube-drawing plant of the Pervouralsk Staro trubnoi Works.

Nikolai Sergeevich Chernykh—senior mill operator at the plate-rolling mill of the Verkh-Isetsk Metallurgical Works.

Pavel Andreevich Chekhovskii—senior foreman at the rail-structural mill of the "Azovstal" Works.

Grigorii Leont'evich Chuiko—senior furnace attendant at the blast-furnace plant of the "Azovstal" Works.

Ivan Ivanovich Chursinov—foreman at the tube-rolling plant of the Pervouralsk Novotrubnoi Works.

Vasilii Andreevich Shkuropat—steel melter at the open-hearth plant of the "Azovstal" Works.

Lev Dmitrievich Iupko—director of the "Zaporozhstal" Works.

Maksim Gavrilovich Shcherbina—senior mill operator at the section mill of the Petrovskii Works.

AN IMPORTANT LANDMARK IN THE DEVELOPMENT OF THE IRON AND STEEL INDUSTRY IN EAST SIBERIA

From August 18 to 26, 1958, a conference on the development of the productive capacities of East Siberia took place in Irkutsk. At the Conference and at preceding regional meetings at Krasnoyarsk, Irkutsk, Kyzyl, Yakutsk, Ulan-Ude and Chita, more than 700 papers on various problems of the development of productive capacities of East Siberia were presented. As a result of detailed discussion in which more than 1500 workers of science and industry took part, the mineral and plant resources, power resources, the prospects of the development of industry, transport and agriculture, were scientifically evaluated.

The iron and steel industry has to play an important part in the development of the extensive industry of East Siberia. Extremely rich resources of iron ore and coking coal, cheap thermal and hydraulic electric power, nonore raw materials and constructional materials, and the growing demand for ferrous metals make possible and necessitate the construction of large metallurgical works. The problems of the development of the iron and steel industry in East Siberia were considered very extensively at the Conference and at the regional meetings.

A comprehensive paper on the prospects of the development of the iron and steel industry in East Siberia was presented by the Vice-President of the Academy of Sciences of the USSR, I. P. Bardin. He stressed the expediency of building, first of all, the Taishet Works in the Irkutsk Province of East Siberia. Iron ore for this works will be provided by the Korshunovo and Rudnogora deposits of the Angara-Ilimsk iron-ore basin. A second works to be built in East Siberia should be, according to Academician I. P. Bardin, a works in the Krasnoyarsk Territory which would be based on the Nizhne-Angara deposits of the Angara-Pit iron-ore basin, and only then should a new iron and steel works in Zabaikal'e (Transbaikal region) be built.

V. S. Nemchinov, the Chairman of the Council of the Acad. Sci. USSR, for the Study of the Productive Capacities, said that the ore-beneficiation combines which will be built in the near future in the Angara-Ilimsk and the Angara-Pit iron-ore basins, will be in a position to supply not only two East Siberian iron and steel works in the Irkutsk Province and the Krasnoyarsk Territory but also the West Siberian iron and steel industry with raw materials prepared for the smelting process.

Academician V. S. Nemchinov considered that it is possible, within the frame of a general plan, to begin the establishment of the fourth iron and steel center of the USSR in Zabaikal'e and suggested that in the state economic plan for the next seven years provision should be made for a start in planning and designing the industrial establishments (to be built after 1965) of the Zabaikal'e iron and steel industry. Such a start should include, first of all, the construction of a railroad connecting the South Yakutia iron-ore and coal basin with the Trans-Siberian main line. It is also necessary to prepare a complex plan of the industrial development of the South Yakutia coal basin and tentative plans including a technical and economical evaluation of various projects of future iron and steel works in Zabaikal'e, and to determine the sequence in which they are to be built.

Basic recommendations and tasks of scientific-research, prospecting and project work related to the development of the iron and steel industry in East Siberia were set out in the resolutions passed by the Section of the Iron and Steel Industry. The more important of these resolutions are:

To continue work on the exploration of the reserves of iron, manganese and chromium ores, coking coal and other raw materials in East Siberia;

To work out a technical and economic basis for the construction of iron and steel works centered on Aldan, Angara-Pit and Berezovo ores, and to determine the most economic sequence in which these works are to be erected;

To investigate the problem of the future requirements of East Siberia and the neighboring regions in rolled-steel products, with a view to determining the type and assortment of rolled products of future East Siberian iron and steel works;

To work out a comprehensive plan of developing the South Yakutia coal basin and to provide for the completion, by 1965, of a railroad which would provide a link between this basin and the Trans-Siberian main line;

To carry out an evaluation of iron ores of East Siberia and of their beneficiation products by means of standard evaluation methods;

To carry out technical investigations of rational methods of the beneficiation of the complex iron ores in East Siberia, with the object of a maximum extraction of valuable components;

To speed up the industrial development of the Tal'skoe magnesite field;

To carry out investigations on the production of metallurgical coke from the coal of the Irkutsk basin, without the addition of coking coal from the Kuznetsk basin in the charge;

To continue the work on the study of prepared metallurgical fuel (continuous coking by the method of IGI Acad. Sci. USSR, granulation of fine coal fractions, briquetting etc.);

To speed up the work on the production of metallurgical coke from the brown coal of East Siberia. To build, by 1960, an experimental industrial plant for the production of coke from brown coal by the method developed by the Moscow Steel Institute;

To advise the design organization to consider, when preparing projects for East Siberia's iron and steel works, the technical and economic advantages of building electric furnaces for pig-iron and steel smelting at those works;

To complete the design of a large capacity, efficient electric furnace;

To speed up the design and construction of the experimental industrial electric furnace at the "Sibelektrostal" Works for smelting pig iron from various ores with the use of various reducing agents, with the object of determining technological and economic indices;

To design and erect, at the "Sibelektrostal" Works, side by side with the experimental industrial furnace, a plant for the compacting and preliminary reduction of iron-ore charge for the electric smelting process;

To expand and modernize, in the next few years, the "Sibelektrostal" Works, for the purpose of providing for the demand for quality steel in East Siberia;

To set up an East Siberia Iron and Steel Scientific Research Institute on the basis of the experimental production at the "Sibelektrostal" Works.

The Conference on the Development of the productive capacities of East Siberia was a significant even in the process of bringing the natural resources of this rich region of our country into the active use for the benefit of our motherland; the work of the Conference will have a beneficial effect on the development of a powerful iron and steel industry in East Siberia.

Cand. Econ. Sci. A. B. ROZENTRETER

BLAST-FURNACE PRODUCTION

AIR COOLING OF THE HEARTH BOTTOM OF No. 2 BLAST FURNACE

N. V. Krepyshev

Deputy Head of the Technical Department of the Kuznetsk Metallurgical Combine

In the investigation of the causes of breakouts of iron, it was found that all accidents without exception were the result either of a faulty design of the hearth and the foundation, or of the use of unsuitable materials of construction, or, finally, the unsatisfactory quality of the erection work.

In the thirties, blast furnaces of more than 800 cu m in volume were built. After a relatively short period of time, however, deep holes in the hearth and cracks in the foundation of these furnaces appeared and that was explained, in the main, by a nonuniform settlement as a result of using one standard foundation for erecting the furnaces on various types of soil. Therefore, when new furnaces were erected according to a second standard design, the construction was modified every time depending on the soil conditions.

All this attracted serious attention to the study of the operating conditions of the hearth and the foundation. As early as 1938, thermocouples began to be set up in the foundation of blast furnaces. The first observations showed that the temperature under the hearth reaches 750-800°C.

The temperature of the foundation increases with the erosion of the hearth bottom, and in some furnaces the temperature of the concrete of the upper part of the foundation was reaching 1000-1100°C. At such a temperature, an ordinary concrete and its reinforcement lose their strength.

Thus, it was established that one of the main causes of crack formation in the blast-furnace foundation is its nonuniform temperature. The first works in which the thermal aspects of the operating conditions of the hearth and foundation were considered, were published. No radical changes, however, were introduced in the design of the lower part of the blast furnaces under construction.

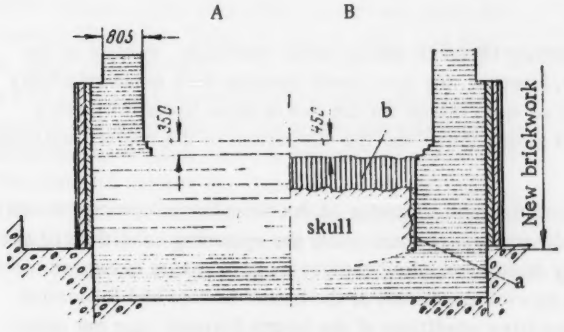


Fig. 1. Initial design of the hearth bottom: A) in the construction of furnaces (1932-1939) B) after first major overhaul; a) chrome-iron ore; b) rails, 700 mm long (figures without brackets refer to furnaces No. 1 and No. 2, figures in brackets refer to furnaces No. 3 and No. 4).

The first basically new design of the hearth and foundation of the blast furnace was proposed by I. G. Polovchenko and I. D. Semikin. * They made, in the main, a correct analysis of the causes of the unsatisfactory service of the hearth bottom and the foundation, and submitted for consideration the proposal of providing a cooling of the hearth from below and, in this connection, reducing the thickness of the hearth bottom. However, the system of cooling the hearth bottom with a plate cooler from below in the form proposed was not approved. ** New blast furnaces were constructed with the ordinary cooling system; to reduce the temperature of the foundation, the thickness of the hearth bottom was increased. Substantial changes in the technology of blast-furnace production – the intensification

*Stal', No. 12, 1947.

**A.F. Sheinberg, Stal', No. 12, 1947; N. K. Leonidov, Stal', No. 12, 1947.

of blast-furnace operation by means of humidifying the blast, an increase in the gas pressure and the introduction of fluxed sinter – had a marked effect on the deterioration of the hearth bottom. The increase of the thickness of the hearth bottom to 0.7-0.8 of diameter of the hearth proved to have little effect and did not safeguard against breakouts. It became obvious that the lower part of the hearth bottom had to be cooled.

The blast furnaces of our Combine were put into operation in 1932-1934. The shell of the hearth and the tuyère zone was of cylindrical shape. The thickness of the hearth bottom was about 3.6 m;the brickwork of its lower part to the height of 1 m was laid flat. The bottom was cooled by means of two rows of peripheral plate coolers, which cooled it over approximately 2/3 of its height without reaching the base of the hearth bottom. The chamotte brickwork of the bottom was laid close to its coolers. The foundation base was of cylindrical shape.

During the first major overhaul (1936-1944) the iron, part of which remained on the bottom after the "skull" was tapped, was not removed. The outer part on the circumference of the hearth bottom was dismantled to some distance below the level of the "skull", and a new chamotte brickwork was laid. Crops of rails and blooms were packed onto the "skull" up to the design level of the top of the hearth bottom. The gaps between the rails, as well as between the new brickwork, on the circumference of the hearth bottom and the solidified iron were rammed tightly with chrome-iron ore (Fig. 1).

The durability of the hearth bottom made up in this way was satisfactory: the bottom in furnace No. 4 lasted from December, 1934, till 1953, with a partial repair in 1944. The life of other bottoms was also fairly long. The erosion of the hearth bottom over that period was small: the depth of the hole constituted 2.0-2.5 m.

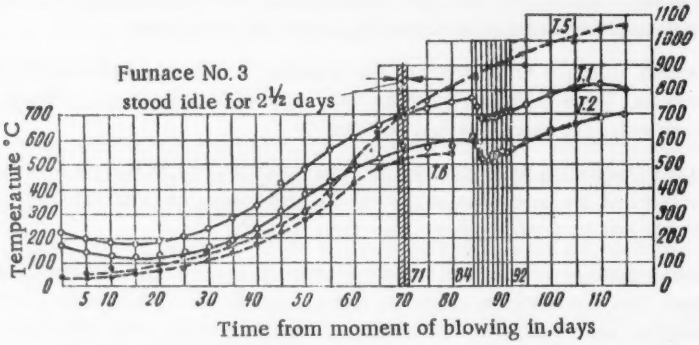


Fig. 2. Readings of the thermocouples placed in the hearth bottom: Furnace No. 1 was blown-in on Nov. 3, 1946, furnace No. 3 on July 2, 1947.

Beginning in 1945, the hearth bottoms were completely replaced during major overhauls. In spite of the increase in the furnace volume and the hearth diameter, however, the new hearth bottoms were made relatively thin (3585-4175 mm), of Semiluki brick, grade D-2 laid on end, except for the two or three lower rows which were laid flat. The cooling system of the hearth as well as the design and the dimensions of the coolers remained the same (Fig. 2).

The increase in the volume of the blast furnaces and the intensification of the blast-furnace process in connection with the introduction of humidified blast and increased gas pressure made the operating conditions of the hearth bottom more rigorous. But their good durability during preceding campaigns gave reason to expect satisfactory service and therefore no serious study of the service conditions of the hearth bottom and foundation was carried out. Thermocouples for investigating the operating conditions of the hearth bottoms were put under the hearth bottom of furnace No. 1 in 1946, and of furnace No. 3 in 1947. The themocouples were put in "for good" without tubes; it was impossible to replace or check them. 4-5 months after the furnaces were blown-in, the readings of the thermocouples reached 700-800°; the thermocouples burnt through and that was the end of the investigation. The recording instruments, however, provided a continuous recording of the readings of the thermocouples. The curves plotted on the basis of these recordings showed that in the first 2-3 months after the blowing-in, the hearth bottoms were heated rapidly.

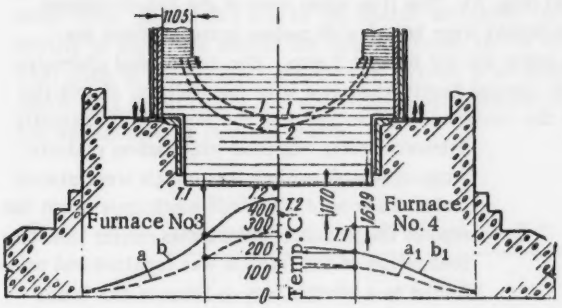


Fig. 3. Design of the hearth bottom of furnaces No. 3 and No. 4 after the renewal repairs (1954):
a) and b) temperature distribution under the hearth bottom of furnace No. 3, by thermocouple readings, 6 months and 18 months, respectively, from the time of blowing-in; a_1) and b_1) the same, in the furnace foundation; 1) and 2) depth of the hole in the hearth bottom of furnaces No. 3 and No. 4 from the data of radiometric measurements 6 months and 18 months respectively from the time of blowing-in.

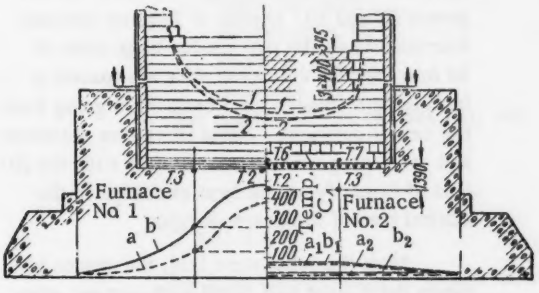


Fig. 4. The hearth bottoms of furnaces No. 1 and No. 2 after repairs, 6 and 18 months, respectively, from the time of blowing-in (blown-in Oct. 4, 1955, and Sept. 8, 1956, respectively):
a) and b) temperature distribution under the hearth bottom of furnace No. 1; a_1) and b_1) the same, of furnaces No. 2 (above the air cooling); a_2 and b_2) the same, of furnace No. 2 (under the air cooling); 1) and 2) erosion holes in the hearth bottoms of furnaces No. 1 and No. 2 from the data of radiometric measurements.

From 1953 onwards, ampoules with radioactive isotopes were inserted into the hearth bottom during major overhauls. Bursts of radioactivity of pig iron provided means for observing the erosion of the hearth bottom.

The investigation of the causes of the breakouts of iron at furnaces No. 3 and No. 4 in 1953, showed that the cause of the breakouts was not so much the formation of a deep hole in the hearth bottom as the appearance of continuous cracks in the foundation. Radial cracks extended to the central line of the foundation which was found actually to be separated into four parts. When the remaining refractory brickwork was pulled down, open joints between the bricks in the direction conciding with the vertical cracks in the foundation, were revealed near the circumference of the lower part of the hearth bottom. All this indicated a connection between the life of the hearth bottom and the foundation. By then, it was realized that under-bottom cooling was necessary, but during the renewal repairs of furnaces No. 3 and No. 4 there was no time for installing the under-bottom cooling system. The first steps, however, in this direction were made.

On the proposal of Academician I. P. Bardin, the cooling of the hearth bottom was improved by installing additional angle-shaped coolers (Fig. 3). In addition, cement solution was poured into the cracks in the foundation; the foundation base was strengthened with a strong reinforced concrete support, and the base plate was strengthened with steel bands. Thus, heat conduction from the lower part of the hearth bottom was enhanced owing to the installation of the additional coolers, and the tightness of this part improved owing to the restoration of the strength and monolithic character of the foundation.

During the repairs of furnace No. 1 in 1955, carbon blocks were laid in the hearth. The hearth bottom was laid with chamotte and the upper 5 rows were made of carbonized brick D-2, with the object of increasing the durability of the hearth bottom. The plate coolers on the circumference were extended down to the base of the hearth bottom.

It was found during the operation of this furnace that the increase in the thickness of the furnace bottom did not eliminate a strong and nonuniform overheating of the foundation (Fig. 4).

In 1956, during the reconstruction of furnace No. 2, it was intended to lay carbon blocks in the bosh, hearth and hearth bottom. In addition, it was planned to use carbon blocks for the outer ring of the hearth bottom and its lower part. For interlinking with carbon blocks, it was planned to use chamotte brick 400 mm high. It was possible, however, to lay only threee rows of the large-size hearth-bottom brick. Carbon blocks in the peripheral

ring of the hearth bottom were laid only in its upper part (Fig. 5). The five upper rows of the hearth bottom were constructed of carbonized chamotte brick. Carbon blocks were bound with carbon material from the Dnepropetrovsk Electrode Factory; the thickness of the joints did not exceed 2 mm. The carbonized chamotte bricks were bound with a medium-thick mixture of finely ground Semiluki mortar with the addition of 15% (by volume) graphite. Gaps between the carbon blocks and the coolers as well as between the blocks and chamotte brickwork were rammed with carbon material. Ampoules with radioactive cobalt were placed under the second, fifth and ninth rows (from the top) of the hearth bottom on its center line. The foundation of the furnace was repaired and reinforced in a similar way to furnace No. 3 and No. 4 in 1953-1954. In addition the pressure of the elevated soil on the foundation of furnace No. 2 from the side of the cast house was relieved by constructing a supporting wall. Instead of an elevated-ground operation floor at the hearth, a reinforced-concrete platform was erected so that the hearth was left half exposed.

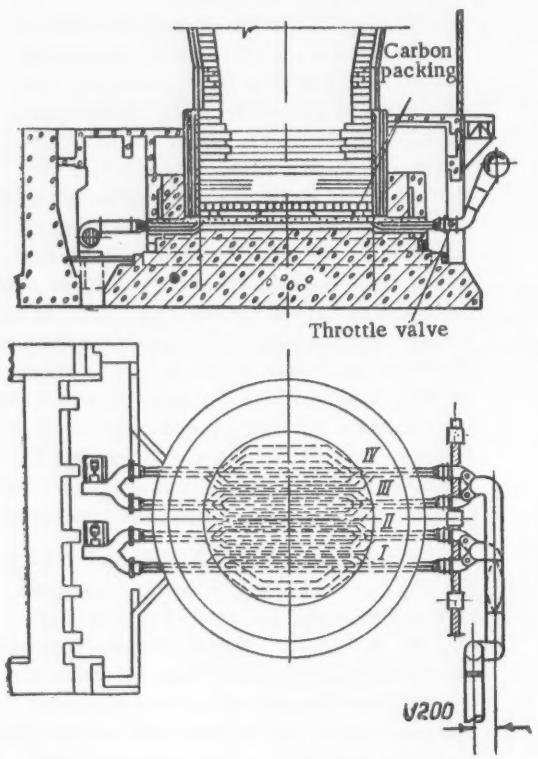


Fig. 5. Air cooling system of the hearth bottom of furnace No. 2.

The under-bottom air-cooling system was made in the form of four groups of one-piece steel tubes (9 tubes in each group), placed on top of a concrete bed (Fig. 5) and taken out through the holes drilled in the circular concrete wall and then cemented up. The two central groups (II and III) consist of 148 mm internal diameter tubes, the two outside have tubes of 94 mm internal diameter; they are spaced at increasing distances from each other going from the center outwards. Tubes of various diameters and at varying spacing were chosen with the object of intensifying the heat exchange in the central part of the hearth bottom.

After the tubes were laid, the spaces between them were half filled with cement mixture and then carbon material was rammed on top of them. Thermocouples were inserted under the tubes. Two blowers of 22.000 cu m/hrs capacity at a pressure of 150 mm of water were installed to supply air for cooling. Each blower supplies two groups of tubes. The air after passing through the cooling system is released through the exhaust tube into the atmosphere.

After the reconstruction, blast furnace No. 2 was blown in on September 8, 1956. Up to September 16, casting pig iron was produced. By October 1, 1956, the blast was increased to 2500 cu m/min, the blast humidity to 25 g/cu m and the top pressure to 0.5 atm.

The basic operating statistics of the furnace from November, 1956 to April, 1958 are given in Table 1.

The air bottom-cooling system was switched on in the first days of October, 1956. The operating indices of sections 1 and 2 of the cooling system are shown in Table 2.

The total amount of heat taken out by the cooling system in the period from May to August, 1958, was 69.200 kcal/hr or 19.9 kcal/min· sq m of the surface area of the bottom base. Heat removed from the side surfaces of the bottom by the plate coolers (May, 1958) constituted 42.6 kcal/min· sq m.

The thermocouples inserted in the foundation concrete in the layer of carbon packing above the tubes were connected to recording instruments immediately after the furnace had been blown in. Changes in the temperature of the bottom and of the foundation in comparison with other furnaces are shown in Table 3, from which it

is seen that, at present, the temperature under the bottom of all the blast furnaces has become stabilized. At the same time, the service life of the hearth-bottom of furnaces No. 1, 3 and 4 will depend to a great extent on the ability of the lower part of the hearth bottom and of the foundation to withstand the thermal stresses which appear even at the present temperature. There is no doubt about the service of the hearth bottom of furnace No. 2, since, as a result of the low and uniform temperature of the hearth bottom and the foundation, one need not fear the appearance of thermal cracks.

TABLE 1

Operating Statistics of Furnace No. 2

Item	Mean figure for periods		
	Nov. 1956 to Apr. 1957	Nov. 1957	Nov. 1957 to May 1958
Ratio of blast furnace useful volume to daily output	0.672	0.660	0.660
Consumption of materials, kg/t:			
iron ore	747	432	555
fluxed sinter	1136	1398	1331
metallic additions	30	38	22
limestone	154	120	89
coke (dry)	701	675	677
Blast:			
input, m^3/min	2503	2449	2440
temperature, °C	844	856	846
pressure, atm	1.80	1.82	1.74
humidity, g/m^3	25.2	24.5	25.5
Gas pressure at the furnace top, atm	0.57	0.68	0.57

TABLE 2

Data on the Operation of Hearth-bottom Air-cooling System (mean figures for periods)

Period	Section 1			Section 2		
	Temperature change of air, °C	Air input, m^3/hr	Heat taken out, kcal/hr	Temperature change of air, °C	Air input, m^3/hr	Heat taken out, kcal/hr
Nov. 1956 to Oct. 1957	4.8	3,780	5,570	3.7	13,200	15,000
May-Oct. 1957 to Nov. 1957	5.5	4,050	6,950	4.0	13,300	17,450
April 1958	7.5	4,300	10,000	5.5	13,600	20,300
May-Aug 1958	7.9	4,500	11,000	5.6	13,600	23,600

TABLE 3

Readings of the Thermocouples in the Hearth Bottom and the Foundation, °C.

Number of months after the blowing-in	Furnace No. 4* (blown-in on January 24, 1954)		Furnace No. 3* (blown-in on February 3, 1954)		Furnace No. 1* (blown-in on October 4, 1955)		Furnace No. 2 (blown-in on September 8, 1956) **			
							above tubes		below tubes	
	Thermocouples									
	Center	Circumference	Center	Circumference	Center	Circumference	Center	Circumference	Center	Circumference
	2	1	2	1	2	3	6	7	2	3
6	130	120	275	162	379	129	52	62	10	10
18	210	190	401	249	470	250	74	70	20	20
22	–	–	–	–	–	–	74	70	20	20
31	229	212	407	232	496	295	–	–	–	–
35	228	210	398	240	497	223	–	–	–	–

*Thermocouples placed 1170-1829 mm below the base of the hearth bottom (Fig. 3).

**Thermocouples placed 1390 mm below the base of the hearth bottom (Fig. 4 and 5).

SUMMARY

1. The air-cooling system of the hearth bottom resulted in a substantial drop and equalization of the temperature of the lower part of the hearth bottom and of the foundation of the furnace.

2. The small change in air temperature indicates that it is possible to lower the output of the blowers used.

3. The relatively rapid deterioration of the upper rows in the hearth bottom indicates that with under-bottom cooling it will be advantageous to reduce the thickness of the hearth bottom considerably.

THE OPERATION OF THE BLAST FURNACE WITH SIZE-GRADED CHARGE

In the Metallurgist No. 5, 1958 we published as a topic for discussion articles by V. E. Levchenko and K. A. Bovkun on the operation of the blast furnace with size-graded charge. Here are comments on these articles.

M. A. Sukonnik

The Krivoi Rog Metallurgical Works

The problem of the operation of blast furnaces with size-graded charge, raised in the articles by V. E. Levchenko and K. A. Bovkun (Metallurgist No. 5, 1958), is a very urgent one. Owing to the improvement in the gas permeability of the stock, the size-grading of the charge makes it possible not only to boost the blast-furnace process but also to reduce coke consumption.

As the basicity of the fluxed sinter from the Krivoi Rog ores is increased, the size of the lumps becomes less and less and the amount of fine fractions increases; this impedes a steady operation of the furnaces and promotes the formation of channels. At the Krivoi Rog Metallurgical Works, even when the furnaces were operated with 100% fluxed sinter in the charge, channeling was observed in the course of the prolonged operation of the furnaces. The nonuniform descent of the stock and the elimination of channeling by means of forced settlement and "blank" rounds for loosening the stock, are bound with an increase in specific coke consumption and a drop in in blast-furnace output. When attempting to avoid irregular operation and channeling, one has to ease the burden at the circumference of the stock of the blast furnace in order to maintain the attained level of boosting of the blast furnace process, by employing alternative charges coke-ore-ore-coke-coke-stone, coke-coke-ore-ore-coke-stone and coke-coke-coke-ore-ore-stone, and by increasing the coke rounds, as this promotes the distribution of large particles near the wall of the stack. With this method of charging, which causes the peripheral passage of gases, the utilization of the thermal and chemical energy of gases deteriorates and hence the consumption of coke increases.

The use of graded sinter (e.g. two fractions, 10-40 and 40-100 mm, the 0-10 mm fraction being eliminated) should promote a somewhat heavier charging of the periphery and a better utilization of gases.

The automation of the blast-furnace process is rather difficult because of the complexity of the process due to the simultaneous effect of a large number of variable factors.

In particular, the particle-size composition of the charge varies from round to round and it affects the blast-furnace process considerably. Size-graded charge will make it possible to stabilize the particle size of the materials in the furnace and will facilitate the automation of the blast-furnace process.

With regard to the ways of improving the utilization of the gas permeability of the charge by means of size grading (for boosting the process or for a better utilization of the gas stream), it should be noted that with the increase in the productive capacity, preference will be given, naturally, to a more economical operation of blast furnaces at a low coke consumption, but at an adequate boosting of the process.

In practice, it is more advantageous to separate the charge according to size directly before it is charged into the furnace and not to screen the charge in advance and keep the separate fractions in bunkers.

In this connection, it is worthwhile considering the scheme of the delivery, screening and charging of the materials into the blast furnace as proposed by R. D. Kamenev and V. N. Fomenko in the article "Charging a large blast furnace with size-graded charge materials" (Metallurgist No. 5, 1958). In that case one should make provision for a maximum removal of dust which forms during the screening of large quantities of materials, in order to ensure proper working conditions in the stock house.

A factor favoring the use of size-graded charge will be the introduction of nodulized materials which will permit the control of particle size.

V. E. Derlugin
Shift Foreman of the Blast-Furnace Plant at the Salda Metallurgical Works.

V. E. Levchenko maintains that "for attaining an efficient operation of the blast-furnace process, one of the requirements with regard to the ore is the size grading of the charge as this makes it possible to boost the blast-furnace process and make savings on coke owing to a more rational distribution of the gas flow over the cross section of the furnace. He did not, however, consider the harmful effect of the fluctuations in the chemical composition of the ore.

In the blast furnaces at our plant, ore from the Atasu mine has been used since April, 1958; the ore supplied is not screened but it is lumpy: 10 mm fractions constitute 5-8% by weight; 30-60mm fraction predominates. The ore, as received by the blast-furnace plant, fluctuates widely in its content of iron and slag-forming constituents. The fluctuations in sulfur content reach up to 0.8%.

Here are the most typical results of chemical composition analysis of the ore in May, 1958, %:

H_2O	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Mn	S	P	Fe
2	23,6	1,7	69,2	2	0,64	—	0,51	0,07	0,02	56
—	9,4	3,4	72,2	5,4	0,32	0,2	0,26	0,037	0,02	55

The blast furnaces are of small volume and have a limited thermal inertia and, hence, react rapidly to any changes in the iron content in the ore. Therefore, it is necessary to operate at a large heat reserve and, hence, the silicon content is increased unnecessarily. In order to avoid the production of inferior pig iron with regard to sulfur content, one has to increase the slag basicity.

Initially, the plant had no space for blending the ore and therefore the ore had to be charged as received, regardless of considerable fluctuations in composition. Later on, however, some space was made available at the ore yard, and the blending of the ore for blast furnace No. 1 was started with the use of two excavators. One of them transfers the ore from the trestle onto a heap and the other loads the ore from the heap into the trolleys, which are taken by electric cars to the skip pit. The ore heap is moved twice.

This procedure did not completely eliminate the fluctuation in iron content, but the fluctuations in slag-forming constituents were eliminated to a considerable extent, as is shown by the results of chemical analysis (the first decade of June, 1958), %:

H_2O	SiO_2	Fe	CaO	Mn	S	P
2	9,6	58	Traces	0,7	0,1	0,02
3	11,6	54	»	0,52	0,1	0,02
2	8,0	56,5	»	0,45	0,12	0,01
1	10,0	56	»	2,7	0,08	0,02
1	9,2	59,4	»	0,51	0,07	0,02

The results of the blending of ore were: until April, 1958, the ratio of blast-furnace useful volume to daily output was 0.9; with the blended Atasu ore, the ratio fell to 0.8 and for furnace No. 1 it frequently reached 0.75. The basicity of the slags was approximately 1.05.

V. E. Levchenko gives as an example the operating statistics of the furnaces at the "Domnarvet" Works. But the remarkable results achieved with these furnaces are due in the first place not to the size grading of the charge but to the beneficiation of iron ores. In Sweden, it is considered economical to subject even the ores which contain 60% iron to substantial beneficiation involving extensive size reduction if the beneficiation ensures the removal of 3-4% silicon.

It is known that our leading iron and steel works – the Kuznetsk Metallurgical Combine and the Magnitogorsk Metallurgical Combine – improve the technical and economic indices of operation by means of the beneficiation of the charge and subsequent sintering of the enriched concentrates.

With the present design of charging apparatus, which includes the hopper and the bell, it is not possible to prevent the segregation of the ore caused by the variation in particle size. The preparation of ore for the blast-furnace process, beginning from mining, crushing, beneficiation including blending etc., should be centralized at the mines and not at the ore yard of the blast-furnace plant. The ore supplied to the blast-furnace plant should be of high iron content and should vary as little as possible in chemical composition. The less the fluctuation in the composition, the steadier is the blast-furnace operation.

The operation of the blast furnace with the use of size-graded charge, of no constant chemical composition, will not ensure the economical and efficient operation of blast furnaces.

NEW HOSES FOR THE HYDRAULIC SEALING OF SINTERING MACHINES

The Scientific Research Institute of the Rubber Industry has developed flexible pipe for hydraulic sealing of sintering machines supplied for an iron and steel works in India.

The material preparation, design and production of these flexible hoses were mastered at the Leningrad Rubber Products Factory. Experimental specimens of the hose were tested under industrial operating conditions at our sintering plants at the Nizhne-Tagil and Magnitogorsk Combines.

As a result of the tests, it was found that the experimental hoses are by far superior to the present standard hoses with respect to heat resistance, elasticity, resistance to swelling in lubricants, absence of cracks and the length of service life. Thus, up to the time of checking, the experimental hoses at the Nizhne-Tagil Combine have been in operation for 15.5 months and are still working, while the life of the standard hose in the main part of the sintering machine is 4-6 months, and in the tail part of the machine, where the operating conditions are more severe, the life of the standard hose is 1.5 months.

The results of the check on the condition of experimental hoses for the hydraulic sealing of the sintering machines at the Magnitogorsk Metallurgical Combine showed that the hoses in the tail part of the machine were in a satisfactory condition after 11 months of service.

The production of such hoses should be set up to ensure a full supply for all sintering plants in the USSR.

S. L. Usyskina, A. P. Riskina and D. A. Bochkov

Institute of the Rubber Industry.

STEEL SMELTING

IMPROVED PRODUCTION OF CHROME-MOLYBDENUM STEEL

V. P. Bondarev

The "Krasnyi Oktiabr" Works

At the "Krasnyi Oktiabr' " Works, in 1950, at the beginning of the production of chrome-molybdenum steel to be rolled into heavy section of 180-250 mm diameter, extensive macrostructure defects of the type of subskin gas blisters distributed in the form of chains or separate clusters on the cross section of the ingot were observed. The coefficient of steel consumption was 2.37. In 1953-1954 the new technology of the manufacture of steel grades 12MKh and 15KhM, without the preliminary deoxidation with silicon in the furnace, as developed jointly by the Central Works Laboratory and the Acad. of Sciences of the Ukrainian SSR, was adopted. This method made it possible to lower the gas content in the metal and to reduce the amount of defective material due to gas blisters. The ingots, however, were machined or flame-scarfed to a depth of 25-30 mm.

The coefficient of steel consumption for the heats carried out by this method was 1.84-1.69.

In 1957, research work was carried out on the choice of the optimum weight of ingots and the regime of casting, and as a result, it was possible to change to hot charging of ingots and thus to eliminate flame scarfing before the rolling of ingots.

Test heats of chrome-molybdenum steel (12MKh, 15KhM, 12KhMF) were carried out in accordance with the methods employed at the Works, without the preliminary deoxidation in hot-operated open-hearth furnaces. In all, 29 experimental heats were carried out. The charge consisted of purchased fines, molybdenum waste from our own production and conversion pig iron of grades M-1 and M-2. By the beginning of the melt-down period, normal slag of not less than 1.8 basicity was made. After the metal was heated up, iron ore was introduced in one or two rounds, and the slag was run off until not more than 0.015-0.020% P was in the metal.

New slag was made with freshly calcined lime. The duration of the active boiling in the experimental heats varied from 50 to 80 minutes; the slag basicity during the period of active boiling was 2.4-2.9; the content of ferrous oxide in the first slag was, on the average, 8.95%, in the second slag 10.6% and in the final slag 11.0% .

After the desired carbon content in the metal had been attained (0.08-0.10%), preliminarily heated ferrochrome, grades No. 1-2, was introduced into the boiling bath, and after 5-7 minutes annealed and heated ferromanganese was added. The mean duration of the ferrochrome treatment was 14 minutes, of the ferromanganese 7 minutes. Chromium losses in burning amounted on the average to 32.2%, manganese losses to 53.0%.

As a rule, the bath was boiling slightly during the tapping of the metal. The metal was finally deoxidized in the ladle with 45% ferrosilicon and aluminum in the amount of 450 g/ton. After it had been tapped, the metal was kept in the ladle for at least 15 minutes. The temperature in the furnace at the time of tapping was 1630-1660°C (measured with an immersion thermocouple).

According to the old procedure, the chrome-molybdenum steels were cast into 5.0-ton ingots. As a rule, a clear metal surface was maintained in the mold during the pouring up to the level of the hot top. After the hot top was filled and the surface of the metal was covered with lunkerite,* the ingots were kept in the molds for 8 hrs and then transferred to the conditioning section of the blooming mill where the ingots were flame-scarfed over the whole surface area to a depth of 25-30 mm.

Before being rolled, the ingots were heated in a continuous furnace. They were rolled on the blooming mill and heavy-section mill into the final section, 180-250 mm in diameter.

*As in original. — Publisher's note.

Chrome-molybdenum steel from the experimental heats was cast into 6.1-ton ingots. The molds were coated with dehydrated coal varnish of not more than 0.5% moisture content.

Before the molds were filled, wooden frames, which prevent the formation of thick skin on the surface of the rising metal in the mold and create a reducing atmosphere, were inserted into the molds. For the purpose of checking the pouring process, one mold on each bottom-plate assembly was used without a wooden frame.

The rate of pouring was adjusted so that up to 1/3 of the height of the mold the rising metal had a clear surface and then a skin and a liquid welt of 25-35 mm at the walls of the mold was formed. When the hot top was filled to 2/3 of its height, grade L-28 lunkerite was spread onto the surface of the metal and then some more metal was slowly added to fill the hot top up to the desired level.

The ingots were kept in the mold for 2 hours 30 minutes and then were transferred hot to be placed in soaking pits for heating up, and then were rolled in accordance with the accepted procedure.

Chrome-molybdenum steels made in small open-hearth furnaces without a preliminary deoxidation and cast into 6.1-ton ingots exhibit, as a rule, a satisfactory quality of the macrostructure and surface of rolled products.

The introduction of 6.1-ton ingots made it possible to eliminate the subskin gas blisters in the metal almost completely. The steel from only one heat exhibited gas blisters in the sample marked 3A. For two heats, bars marked 8A from top-poured ingots were found defective.

Ingots from all the experimental heats were rolled on the blooming mill and heavy-section mill into final sections of 150-250 mm diameter. After they had been rolled, the bars were placed into pits where they were cooling slowly for 72 hrs. Each bar was then thoroughly inspected and surface conditioned.

The inspection showed that the predominant defects on the surface of the large-section finished rolled product were cracks and fissures but the number of the defects was very small.

The grading of the rolled bars showed that the yield of metal after the first stage of conditioning was 95.4% which constitutes quite a satisfactory result.

The technical specifications for alloyed tube billets from steels 15KhM, 12MKh and 12KhMF (by TU 2581)* permit the contamination of steel with nonmetallic inclusions to be of not more than mark 3** with respect to oxides and not more than mark 3.5 for sulfides. The mean mark for oxides in the experimental heats was 2.27 and in only one heat the metal had mark 3.0 with respect to oxide contaminations.

The mean mark for sulfides in the experimental heats was 2.89; the minimum mark was 2.16 and the maximum 3.5 (in one heat).

The results of mechanical tests on large-section chrome-molybdenum steel from the experimental heats showed that the mechanical properties of all grades of that steel are quite satisfactory and exceed the specifications given by TU.

Thus, the ultimate tensile strength of steel 12KhMF exceeds the TU specifications by 42%, the yield point by 74%, the elongation by 20%, the compression by 17% and the impact strength by a factor of 3.

For steel 15KhM, the ultimate tensile strength is greater by 26% than that specified by TU, the yield point by 70%, the elongation by 20%, the reduction of area by 64% and the impact strength by a factor of more than 5.

During production by the old method, the losses of metal after the ingots were cast constituted 35% and, correspondingly, the coefficient of consumption was 1.6-1.7. When the 6.1-ton ingot was adopted, the coefficient of consumption fell to 1.47.

*TU, Technical specifications.

**Mark - Scale defined by Soviet Standard specifications.

REDUCING THE CONSUMPTION OF METAL ON CASTING INGOTS FOR FORGING

Engineers V. A. Malyshev and A. F. Gorbachev, and Cand. of Tech. Sci. A. G. Papush

Electric heating of the hot top of ingots results in a considerable saving of steel, owing to the fact that the hot top is not completely filled without affecting the quality of the ingot. Electric heating completely eliminates the axial porosity and sponginess of ingots. Therefore, since August, 1955, the Il'ich Works has introduced electric heating of the hot top of large forging ingots of carbon and alloy steels.

Experience showed that during the stripping of ingots which were electrically heated, some difficulties are encountered because of the reduced height of the hot top since the existing strippers were designed for a minimum height of the hot top equal to 600 mm. In addition, it is difficult to forge an ingot with a short hot top because of the the short length of metal which can be gripped by the manipulator tongs.

In February, 1957, the level of the steel in the hot top was raised and this resulted in a decrease in the average annual saving of metal from 6 to 5 %. But even this did not eliminate the difficulties in stripping and forging the ingots. Any further increase in the height of the hot top was uneconomical since the savings in material would be markedly reduced. Therefore, it was decided to combine the method of electric heating with the increase in the height and the reduction in the diameter of the ingot hot top. Preliminary thermotechnical calculations showed that the diameter of the hot top can be reduced by 200 mm by increasing the thickness of the hot top lining to 160 mm instead of the usual 50 mm, without a deterioration in the metal flow into the hot top during the period of ingot crystallization. Sketches of hot tops with the ordinary and the thicker lining for ingots of 38.0 tons are shown in Fig. 1.

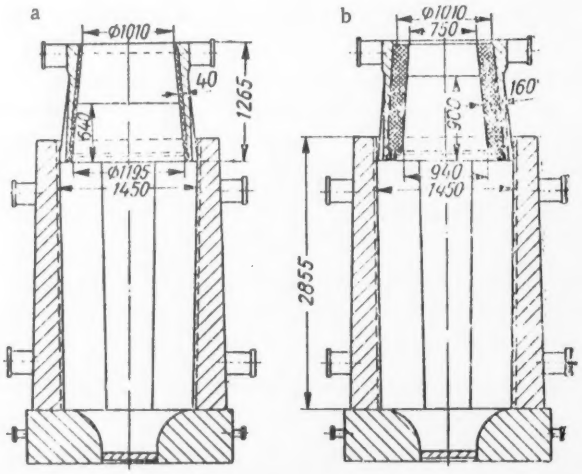


Fig. 1. Mold with the ordinary (a) and the improved (b) hot top

The effect of the thick lining of the hot top on the ingot quality was studied on two ingots of nominal weight, 38 tons and 54 tons respectively. In addition, the possibility of casting large forging ingots with the use of the thick-lined hot top but without applying electric heating was also tested. For this purpose, an ingot of 35.2 tons nominal weight was cast in the mold of 30.5-39.5 type, filled with a hot top whose lining was 160 mm thick. The data on the casting of the test ingots are given in the Table.

As is seen from the Table, the actual weight of the ingot cast of steel 60 KhG constituted 34.7 tons while its nominal weight was 38 tons, the steel savings amounting thus to 8.7% as compared with 7.5% for the case when

electric heating was applied to ingots with a hot top of ordinary shape. At the same time, the height of the hard part of the hot top was increased by 200 mm. The second experimental ingot of steel 55Kh weighed 51.4 tons, the steel savings constituting 4.8% as compared with 3.7% for the ingot of the same type, heated electrically, but with an ordinary hot top. The height of the hard part of this ingot was increased by 210 mm. The third experimental ingot of steel grade 55 was cast without the electric heating of the hot top, weight of the metal in the hot top being reduced by 5% owing to the increased thickness of the hot top lining; the surface of the metal was covered with ordinary chamotte powder.

When the ingots were forged under the press, the hot top, including about 300 mm of the ingot body, was separated and a longitudinal section specimen was prepared. The remaining part of the ingot was used for forging.

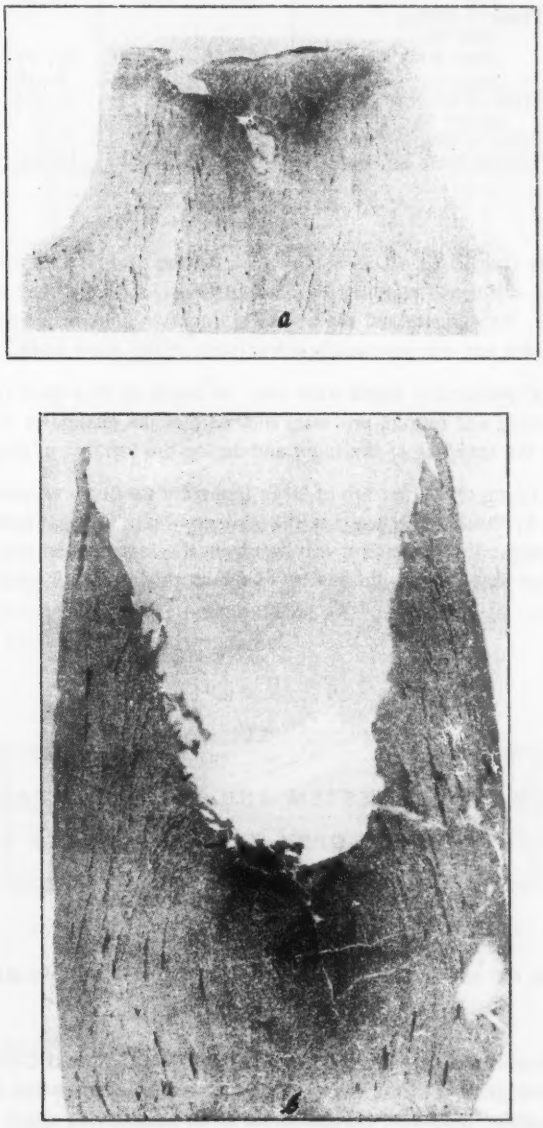


Fig. 2. Sulfur prints of the ingot hot top:
a) 38-ton ingot, electrically heated when cast b) 35.2-ton ingot, cast without electric heating

Data on the Casting of Experimental Ingots

Parameter	Conditions of casting		
	with electric heating		without electric heating
Steel grade	60ХГ	55Х	55
Ingot weight, nominal	38	54	35,2
actual	34,7	51,4	34,2
Height of the hot top, mm	900	1100	1150
Time of filling min-sec ingot body	12—00	12—30	12—10
ingot hot top	5—00	5—30	5—10
Time of electric heating of hot top, hrs	5,0	6,0	—
Time of keeping the ingot in the mold, hrs-min	9—07	9—03	13—58

Sulfur prints were taken from the surface of the specimens and samples of metal were taken for the chemical determination of carbon, sulfur and phosphorus. The sulfur prints (Fig. 2) and the results of the chemical analysis showed that the pipe, the porosity and the coarse segregation zone of all experimental ingots lie above the level of the hot-top shoulder and are practically nonexistent in the ingot body.

Next, four experimental production ingots were cast in molds of 30.5-39.0 type without being electrically heated. The study of the casting and forging processes showed that the change in the shape of the hot top does not cause any difficulties during the stripping of the ingot and during the forming of the end for the holder.

The thickening of the lining of the hot top of large ingots for forging was made use of in experimental work which was conducted jointly by the Il'ich Works and the Zhdanov Metallurgical Institute on increasing the taper of the ingot. The study of longitudinal-section specimens from the ingots under test showed that in spite of a substantial reduction in the hot-top weight, the quality of the metal in those ingots was not impaired.

IMPROVEMENT OF THE SYSTEM AND INSTRUMENTATION OF THE AUTOMATIC CONTROL OF THE OPEN-HEARTH FURNACE THERMAL REGIME

N. S. Skorik

Deputy Head of the KIP* and Automation Shop at the Nizhne-Tagil Metallurgical Combine

Large-capacity open-hearth furnaces at the Nizhne-Tagil Metallurgical Combine are fired with a mixture of coke-oven and blast-furnace gases with the use of oxygen for the intensification of the flame. Tar or anthracene oil are used as carburetting agents. Industrial oxygen serves as an intensifying agent.

Oxygen is fed to the flame in the open-hearth furnace through oxygen tubes fitted with stainless-steel nozzles 25 mm in diameter. The tubes, mounted in water-cooled tuyeres, are placed on both sides of each port (two in each port end), flush with its end part at a height of 200 mm above the bottom of the gas port, at an angle of 8° to the surface of the metal. The carburetting material is fed through tuyères mounted in the roof of the slag pockets. Air for gas combustion is supplied from a No. 12 Sirocco blower.

*Control and measuring instruments — Publisher's note.

The furnaces are equipped with Shvir* valves with water seal on the gas duct, and with Blau-Noks* valves and dampers on the air duct. The controlling valve of the common flue and in the flue gas duct of the air regenerator, and the reversing valves are electrified.

By making use of accumulated experience on the operation of the thermal control and automation of open-hearth furnaces, and also taking into account a great number of requirements set out by the operating personnel in connection with the change over to chrome-magnesite roofs, with the introduction of oxygen, etc., the Combine improved the existing systems of heat control and developed new schemes of automatic control for the thermal regime of open-hearth furnaces, which schemes ensure a better and more reliable control of the thermal regime.

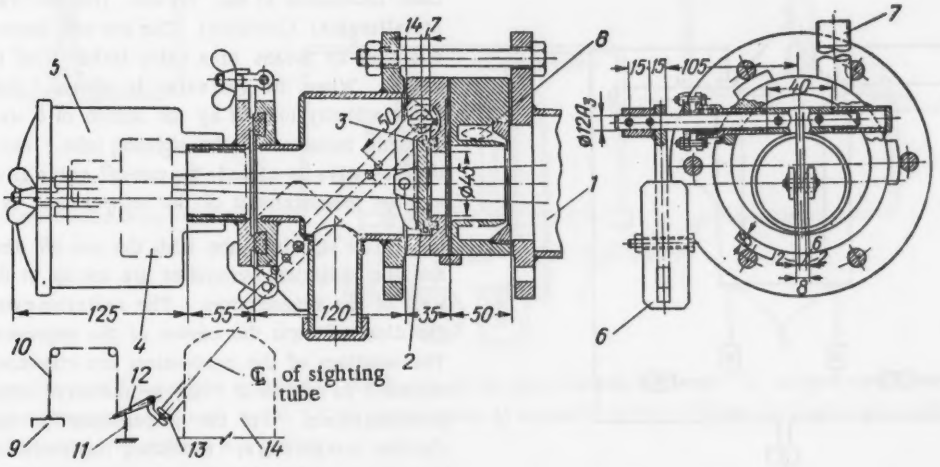


Fig. 1. Apparatus for measuring the temperature of gas checkers
1) sighting tube; 2) cut-off valve; 3) sealing ring; 4) radiation pyrometer; 5) protecting jacket of the radiation pyrometer; 6) counterweight; 7) compressed-air feed tube; 8) place of compressed air delivery for blowing off the flame; 9) gas valve; 10 cable; 11) spring; 12) lever; 13) blow-off valve; 14) gas regenerator.

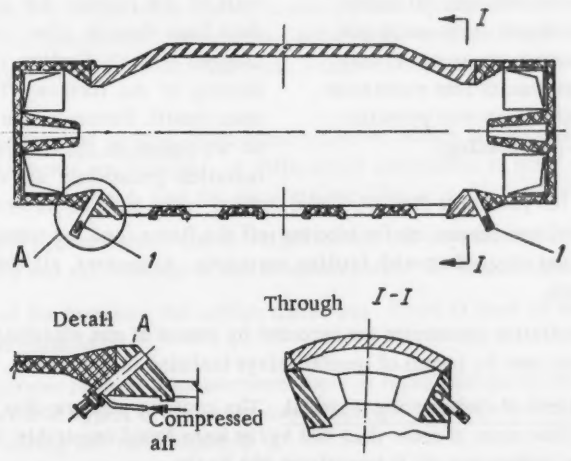


Fig. 2. Diagram showing the method of mounting the tubes (1) for measuring the temperature of the roof of the open-hearth furnace.

*Transliteration of Russian. – Publisher's note.

Control of the thermal regime. On the temperature of the regenerator checkers and, consequently, on the temperature of the gas being heated, depends the degree of the decomposition of heavy hydrocarbons, which are in the gas, and the luminosity of the flame in the working space of the furnace. Previously, the temperature of the top of the gas regenerator checkers was not measured. It is impossible to measure the temperature of gas checkers by means of ordinary sighting tubes used for measuring the temperature of air checkers, since during the period of the mixed gas passage through the checkers the compressed air, which enters the sighting tube to blow off the flame, supports the combustion of the gas and so distorts the actual temperature of the checker, smokes up the radiation-pyrometer lenses and causes the erosion of the brickwork where the sighting tubes are mounted.

A special device (Fig. 1) which cuts off the gas when the checker is operated "on gas", has been introduced at the NTMK (Nizhne-Tagil Metallurgical Combine). The cut-off device is operated by means of a cable linked with the gas valve. When the gas valve is opened, the gas is automatically cut off by the action of a weight or a spring mounted at the sighting tube, and when the gas valve is closed, the cut-off valve is opened and the measurement of the temperature is started.

The sighting tube with the cut-off device and the radiation pyrometer are set up in the end wall of the regenerators. The radiation pyrometers are directed onto the center of the regenerator roof. The readings of the pyrometers are continuously recorded in ink on a chart by means of electronic potentiometers. For the measurement of the air checker temperature, recording millivoltmeters have been replaced by better and more accurate automatic electronic potentiometers.

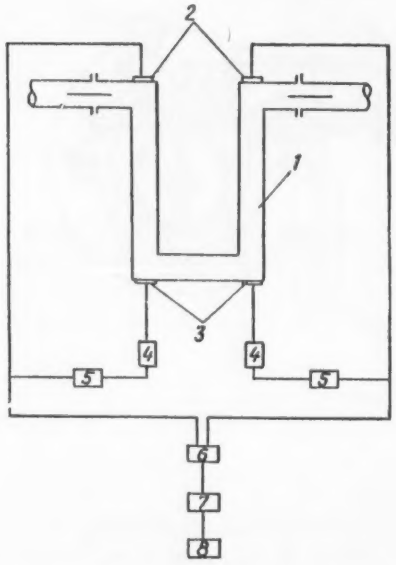


Fig. 3. Basic diagram of the pulsed ultrasonic flowmeter:
1) data transmitter; 2) quartz radiator; 3) quartz receiver; 4) amplifier; 5) formed-stage oscillator 6) unit for difference frequency emission; 7) unit for the transformation of frequencies into equivalent direct voltage; 8) automatic electronic potentiometer which gives the flow-rate readings.

Measurements of the furnace-roof temperature were initially intended to be made at one point only. It was found by experience that the water-cooled sighting tubes mounted at the back wall of the furnace are not reliable in operation; they burn through after 10-20 heats and become clogged up with fettling materials during the fettling of the furnace. Therefore, (at first on one open-hearth furnace) the sighting tubes were fitted at two places in the front wall of the furnace. The radiation pyrometers are directed onto the junction between the main roof and the port roofs (Fig. 2). The sighting tubes have no water-cooling system but provision is made for the supply of compressed air for blowing-off the flame, and the tubes, mounted in the front wall of the furnace, do not get clogged up with fettling materials. At present, all our open-hearth furnaces are provided with this equipment.

The readings of the radiation pyrometer are recorded by means of one electronic potentiometer; the radiation pyrometers are switched over by means of special relays included in the circuit.

Measurement of the input of carburetting material. The constant pressure-drop flowmeter of the PPE type, designed for measuring the flow rates of more than 600 kg/hr were found unsuitable in operation, since the actual consumption of tar or anthracene oil is sometimes 300 kg/hr.

In addition, the orifices of the flowmeter become blocked with solid particles contained in the tar or oil, since the filter of the cleaning system removes only mechanical inclusions of 3 mm diameter upwards. The tested, double-orifice, variable pressure-drop flowmeters which have a constant flow coefficient at small Reynolds numbers were found unsatisfactory.

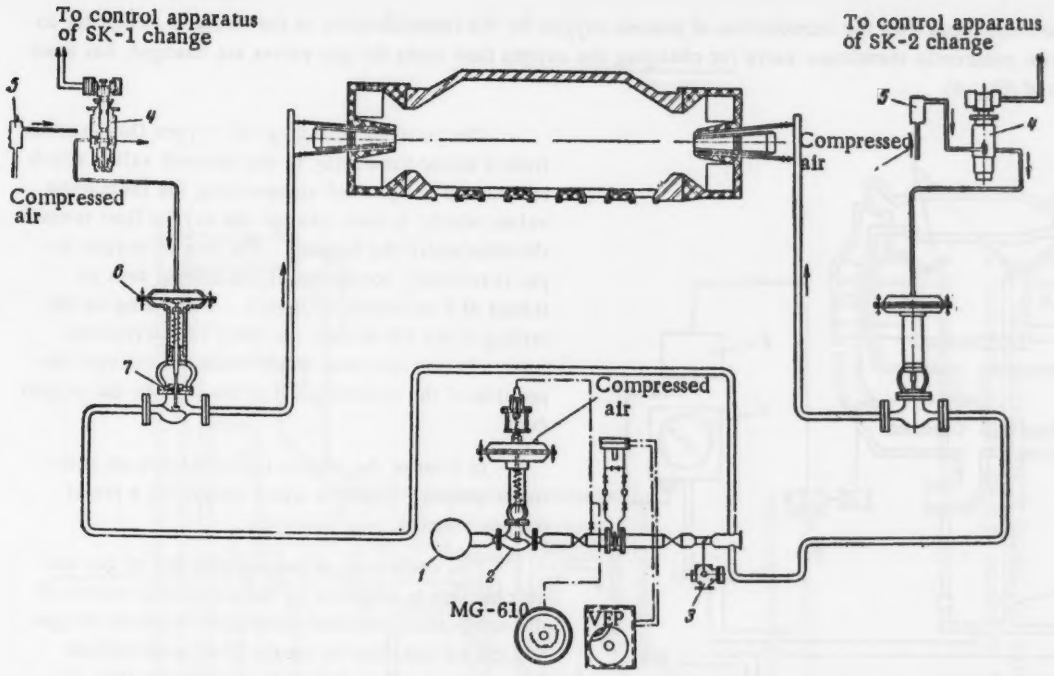


Fig. 4. Flow diagram for oxygen supplied to the flame in the open-hearth furnace: 1) oxygen container; 2) diaphragm pressure regulator; 3) IM 2/120 servomotor; 4) solenoid valve; 5) filter; 6) diaphragm made of technical plate ; 7) stuffing box gasket.

Employees of the "Uralmetallurgavtomatika" have developed and tested a pulsed-ultrasonic flowmeter (Fig. 3) which has no parts or pulse tubes in direct contact with the tar or oil, and is free of the shortcomings mentioned earlier. At present, one complete set of this flowmeter is undergoing tests under industrial conditions.

When tar flows through the data transmitter, the ultrasonic oscillations in one branch of the bend propagate in the direction of the tar flow, and in the other branch in the opposite direction; this results in a difference frequency of oscillations which is transformed into electric oscillations amplified and transformed into an equivalent voltage which is measured by an automatic electronic potentiometer, whose scale is calibrated in the unit of liquid flow.

For measuring the consumption of oxygen, brass-plate chamber orifice meters and membrane differential manometer with auxiliary instruments are installed. A differential manometer is fitted in the oxygen box at the place where the orifice meters are mounted, and the auxiliary recorder is at the furnace control desk.

Initially, the orifices were placed behind the valves which control oxygen input. Hence, the oxygen pressure at the orifice fluctuated rapidly and the readings of the flowmeter were not indicating the true flow rate.

During the cold repairs of the furnaces, the orifice meter was fitted in front of the valves and the effect of changes in oxygen pressure was reduced.

The flowmeter chosen ensures reliable measurements since at rapid changes in the flow rate no sealing liquid, employed in other flowmeter types, is blown out (rapid changes in the flow rate take place as a result of the oxygen flow being cut off during the valve change).

For measuring the temperature of liquid metal, each open-hearth furnace is equipped with an apparatus consisting of a special rapid-immersion thermocouple, automatic recording an electronic potentiometer mounted on the furnace control desk, and a signalling system in the form of a signal light and a loud bell.

In connection with the introduction of process oxygen for the intensification of the flame, a design for an automatic pneumatic membrane valve for changing the oxygen flow when the gas valves are changed, has been developed (Fig. 4).

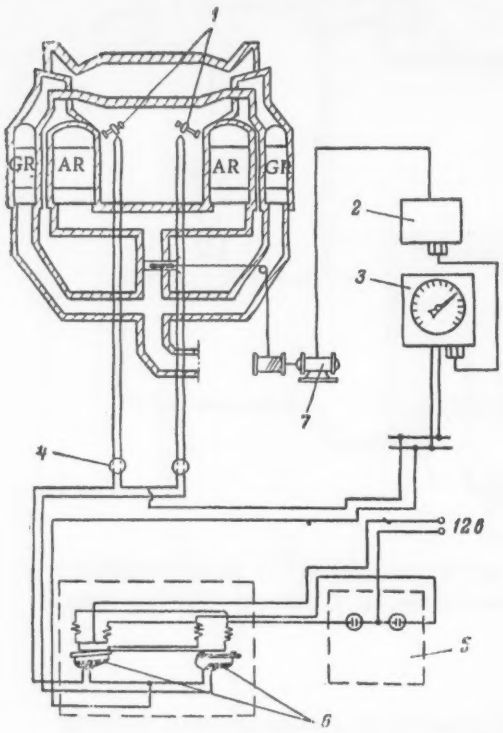


Fig. 5. Basic circuit for the measurement and control of the temperature of the top of regenerator air checkers.
1) radiation pyrometer; 2) magnetic starter; 3) EDP-120 electronic potentiometer; 4) terminal switch; 5) motor time relay; 6) mercury switches; 7) electric motor; AR—air regenerator; GR—gas regenerator.

The pulse for changing the oxygen flow is given from a motor time relay to the solenoid valves which reverse the compressed air operating the membrane valves which, in turn, change the oxygen flow to one or the other end of the furnace. The rate of oxygen input is remotely controlled at the control desk by means of a universal UP switch. Depending on the setting of the UP switch, the IM2/120 servomotor rotates in one direction or the other and changes the position of the revolving valve mounted in the oxygen duct.

In front of the orifice meter there is an automatic pressure regulator which maintains a preset oxygen pressure.

The uniformity of the temperature of gas and air checkers is achieved by the automatic control of the combustion products' distribution between the gas and the air checkers by means of an intermediate damper on the flue of the air regenerators (Fig. 5).

The control impulse comes from the radiation pyrometers which measure the temperature of the air-checker top. The radiation pyrometer which measures the temperature of the heated checker side is connected to the electronic potentiometer during the valve change by means of the terminal switches mounted on the air valves.

If the temperature of the air checkers is higher than that preset on the electronic potentiometer, the regulating damper is slowly closed by means of a hoist, the motor being driven for 2 seconds at a time with a 45-second interval. In 2 seconds the damper moves through approximately 50 mm.

In the case of an instantaneous increase on drop in temperature immediately after the valve change, the damper has no time to change its position markedly. A substantial change in the position of the damper is effected when the temperature exceeds the preset limit in the second half of the cycle between the valve changes. A drop in the temperature of the air checkers below 1100° C is not allowed. If the temperature falls below the preset minimum, the damper is automatically opened.

Owing to the use of the automatic control of the distribution of combustion products between the gas and the air checkers, the uniformity of checker temperature is ensured and the overheating of checkers is prevented.

Automatic control of combustion. The main object of the combustion process control in the open-hearth furnace is to set up a correct ratio of the amount of fuel delivered in the furnace to the amount of air necessary for the combustion and, at the same time, to ensure the maximum pyrometric effect.

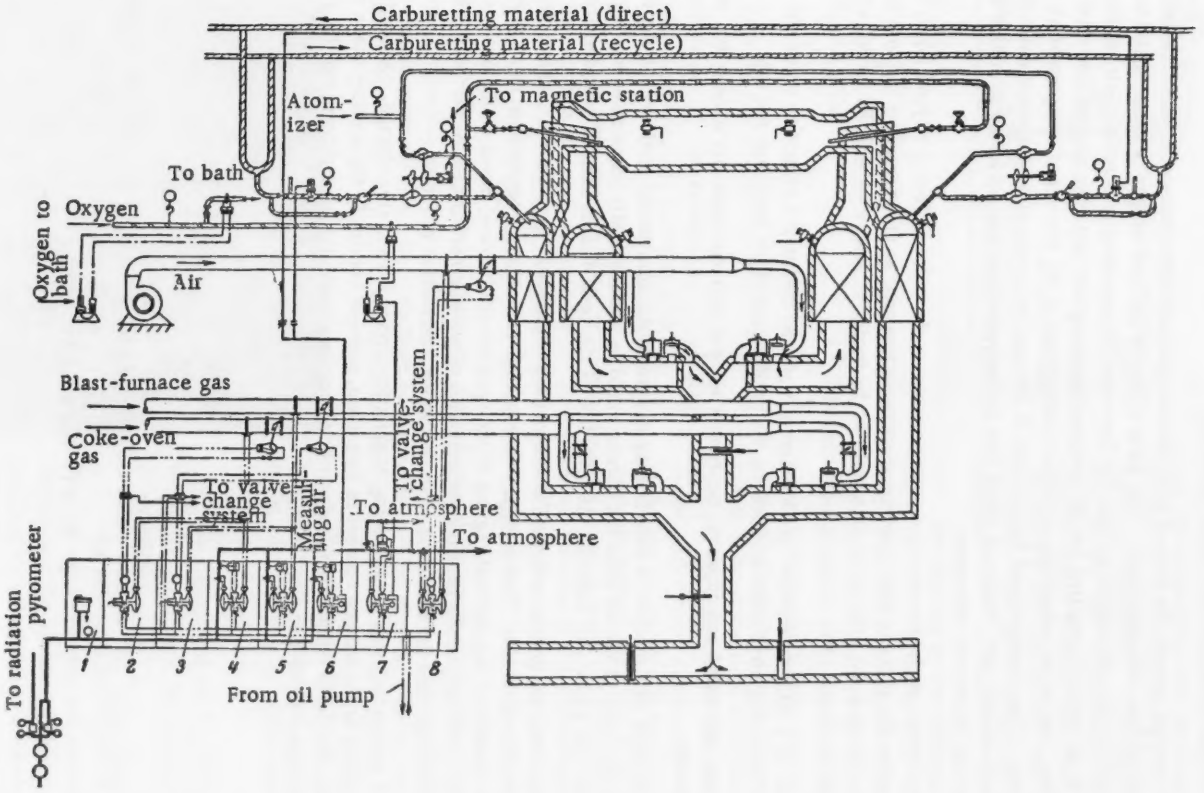


Fig. 6. Basic diagram of combustion control system:
1) control of compressed-air pressure; 2) control of coke-oven gas input; 3) control of blast-furnace gas input; 4) control of air: coke-oven gas ratio; 5) control of air: blast-furnace gas ratio; 6) control of air: fuel-oil ratio; 7) control of oxygen: fuel ratio; 8) control of air: fuel ratio.

The complexity of physicochemical processes, the nonuniform evolution of CO from the bath in the course of the heat, the leakage of cold air and introduction of oxygen into the flame, make the combustion control very difficult.

At open-hearth furnace No. 14, a computer has been installed for the automatic control of combustion (Fig. 6).

The principle of the system consists of the following.

In the adopted control system, the rate of blast-furnace gas and coke-oven gas input is maintained at a preset value by means of flow-rate regulators. The input of liquid fuel and oxygen is preset separately. The flow-rate pulses of each type of fuel are converted into the flow-rate of measuring (controlling) air, equivalent to the theoretical amount of air which is required for the combustion of a given fuel. The oxygen flow-rate pulse is converted into the flow rate of the measuring air which corresponds to the amount of compressed air equivalent to a given oxygen input. The conversion of input pulses is effected by means of ordinary hydraulic flow regulators of the ratio "gas: measuring air". Pulses of liquid fuel and oxygen input are converted by means of hydraulic flow-ratio regulators with electronic converters.

One of the membranes or the electronic transducer receives the pulse of fuel or oxygen input, and the other membrane receives the pressure drop from the diaphragm mounted in the measuring-air duct for the given transducer. By changing the amount of measuring air by means of needle valves, the direct-action servomechanisms maintain the preset ratio of "fuel: measuring air".

Compressed air, at a pressure reduced to 1000 mm of water by means of a reduction valve and a membrane regulator, is used as measuring air. Filters are used for the purification of air from dust and oil.

After it had been assembled and adjusted, the system was put into operation and showed that the computer was functioning correctly.

A successful adoption of a method of determining oxygen in the combustion products and the introduction of a system whereby the input of the air from the blower would be automatically adjusted, depending on the free oxygen content in the flue gases, will improve the operation of the open-hearth furnace considerably.

At present, the Combine, jointly with the "Uralmetallurgavtomatika" and the All-Union Scientific Research Institute of Metallurgical Heat Technology, is conducting work on the development of an integrated system for automatic control of the thermal regime of the open-hearth furnace, based on the automatic control of the thermal regime according to the limiting temperatures of the internal surfaces of the furnace brickwork, the capacity of the flue duct and the condition of the complete combustion of fuel.

The integrated system includes the following automatic-control units: valve change, combustion control and adjustment according to the oxygen content in flue gases, pressure control in the working space of the furnace, the control of the distribution of combustion products between the gas and the air checkers and the automatic control of the thermal load of the furnace.

MAJOR OVERHAUL OF A 260 TON OPEN-HEARTH FURNACE IN 140 HOURS

V. E. Pis'mennikov

In April, 1958, we carried out a major overhaul of a 260-ton open-hearth furnace in a record time – 140 hours.

The steel structures which were dismantled and assembled during the overhaul amounted to about 1300 tons, and the brickwork pulled down and removed, the debris removed, and the new brickwork laid amounted to more than 3000 tons.

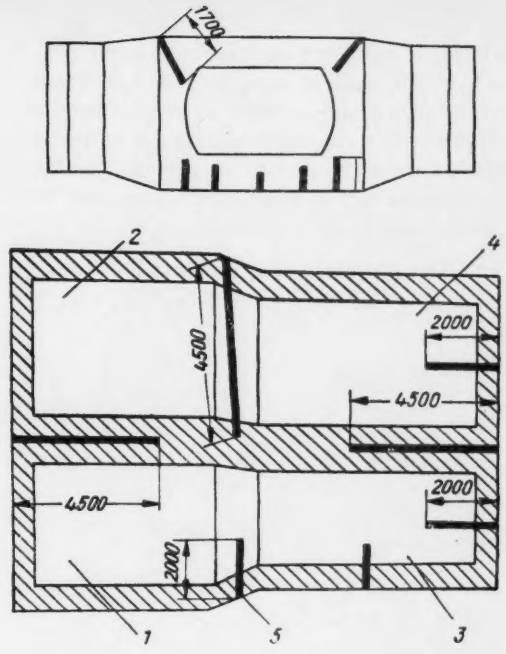


Fig. 1. Positioning of blasting fuses in the furnace brickwork:
1) gas regenerator; 2) air regenerator; 3) gas slag pocket; 4) air slag pocket; 5) partition wall.

The upper structure of the furnace was dismantled completely down to the bed plates of the reinforced concrete buckstays, and the lower part of the furnace down to the slag pockets. The refractory brickwork was removed completely. The brickwork in the regenerators was removed below the level of the lower framework of the regenerator's structure. The checkers of the regenerators and the underchecker equipment were replaced completely, and the flues and the smokestack were repaired in part; the outer framework of the slag pockets and regenerators was replaced completely. The supporting columns of the slag pockets and regenerators were put in the original design position and some of the columns and the shell of the slag pockets and regenerators were replaced. The valve-change apparatus was completely renewed.

For blasting up the refractory brickwork, blasting holes, 130 mm in diameter and more than 4 m deep, were drilled by means of a drilling machine in positions as shown on Fig. 1., before the furnace was shut down for repairs. Two hours after the furnace was shut down, the bottom part of the furnace was blown up in one blast with the use of the blasting fuse, and then the demolition work was started on the remaining brickwork, which was removed by two bulldozers with special attachments. After the removal of the old brickwork and debris from the slag pockets, from the vertical ducts and from the roof of the slag pocket, and after the front upperstructure of the slag pocket was pulled down, the bulldozers were driven backwards into the regenerators and were used for the demolition and removal of the remaining refractory brickwork. In this way manual labor on the demolition and removal of brickwork was completely eliminated. The whole operation of the demolition and removal of brickwork took about 24 hrs.

At the time when the last heat was tapped, the second and the fourth facing steel plates at the back of the furnace were dismantled, and 4 blast holes, 1.5 and 1.6 m long, were drilled under the bottom "skull", and 2 holes were drilled under the banks from the front of the furnace. 7 hrs after the furnace was shut down, the blasting was carried out. In this way, the whole upper structure of the furnace was demolished.

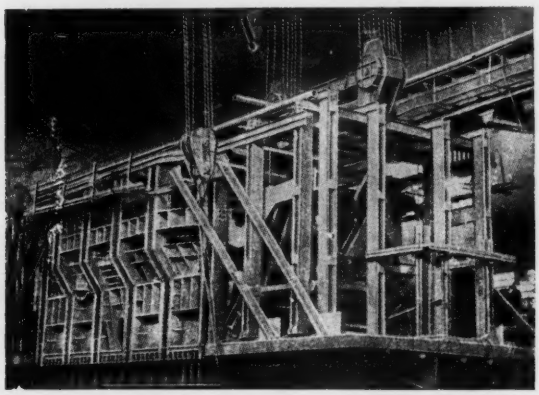


Fig. 2. Lifting the framework of the upper structure of the furnace

Old brickwork, debris and slag was loaded into dump cars by means of a grab crane, suspended on auxiliary pulleys of the pouring crane, and taken out of the plant.

For cooling the hot brickwork, two hydraulic excavators were used, and the brickwork was cooled down quickly.

The new steel framework of the upper structure of the furnace was assembled before the shutdown of the furnace, transported by means of two pouring cranes onto a temporary foundation and lifted by means of two hoists into the final position (Fig. 2). The framing of the main roof was also assembled before the shutdown of the furnace. The upper structure of the furnace was

ready for bricklaying in 56 hrs, the lower in 61 hrs. The bricklaying of refractory brick was carried out by a multistage method, i.e. the laying of regenerator and slag-pocket walls, vertical channels, main roof, hearth and walls of the furnace proper, and the repair of flues and valve-change equipment were carried out simultaneously. The refractory brick was delivered to the construction places by a system of movable and stationary transporters, a mechanical loader and 25-t containers. In addition, for the first time in metallurgical practice, four-axle railroad cars, loaded with brick, were placed directly at the furnace so that the bricklayer could be supplied with brick continuously and a smooth operation of other furnaces could be ensured.

The schedule of repair work was worked out and approved before the shutdown of the furnace.

ROLLED AND TUBULAR PRODUCT INDUSTRY

THE ROLLING OF WIRE ROD ON THE CONTINUOUS WIRE MILL

V. S. Makarenko

Senior Foreman at the Wire Mill of the Krivoi Rog Metallurgical Works

The continuous wire mill was put into operation in April, 1957; it was intended for rolling wire rod, 5-10 mm in diameter from carbon steel. The initial material is square billets of 60 mm side, 12 m long and 330 kg in weight, supplied by the Petrovskii and the "Azovstal" Works.

Billets from the pile are placed, according to their mark, on two charging grates consisting of sets of movable and stationary beams. By executing a cyclic motion the movable beams move the billets forward to the roller table which leads to the furnace. Only one billet enters the roller table at a time owing to hooks which are fitted to the end of the beams and which separate billets one from another. Carrying capacity of the grate is 30 tons and the width of its receiving part is 4 m. The speed of ingot movement is 2.04 m/sec at the start and 2.5 m/sec at normal operation.

From the roller table, the billets enter the furnace by means of a charging device mounted on a special buggy on rails. The speed of charging the ingots into the furnace is 2.5 m/sec, and the capacity of the furnace is 84 tons.

In the reheating furnace, the billets are moved forward by means of an eight-lever pusher. The pushing force is 42 tons, the lever stroke 500 mm and the speed of pushing 0.18 m/sec.

The furnace for heating the billets is of two-zone recuperative type (designed by the Stal'proekt). It has a suspension roof, inclined hearth (8° 15') and is equipped with injection burners, 14 in each zone. The working area of the hearth is 180 cu m, its capacity 550 kg/cu m and the furnace output 100-120 tons/hr. The furnace is fired with mixed (coke-oven and blast-furnace) gas of 1400 kcal/cu m calorific value. The temperature in the soaking and the heating zones is 1350° C, and at the charging door it is 800-1100°C.

The furnace is provided with a ceramic countercurrent recuperator (checkers volume = 270 cu m) for heating the air to 500°C, and with a tubular recuperator of 425 sq m heating surface area for heating the gas to 200°C. The heating regime is controlled automatically. The temperature to which the material is heated is determined according to the steel grade: St. 0-St. 3 — 1230-1280°C; St. 4 — 1200-1240°C; St.5 — 1160-1200°C; St.6 — 1140-1180°C.

The heated billets are discharged from the furnace through a side door by means of a bar-type pusher. The force of the pusher bar is about 900 kg and its speed 1.5 m/sec.

Between the furnace and the first roughing stand there is a distributing and pulling-out apparatus mounted on a special trolley on rails. It consists of a distributor (cylinder type) for distributing billets to separate lines, a pulling-out device and an emergency pulling-out device. The pulling force of the rollers is 312 kg and the speed is 1.55 m/sec.

The mill consists of 39 stands in four groups: roughing, first and second intermediate, and finishing (Fig.1). The rolling in the roughing (Fig. 2) and the first intermediate groups is carried out in four lines.

The roll housing of the horizontal stands are of open-top type, made of cast steel. The working rolls of the roughing group are mounted on roller bearings type TsKB-857, TsKB-856, TsKB-855, TsKB-854. They are lubricated by means of a central system of heavy lubrication. The rolls are assembled by hand: the upper roll is inserted through the upper screw-down screws by means of a hand wheel, and the lower through the lower tightening

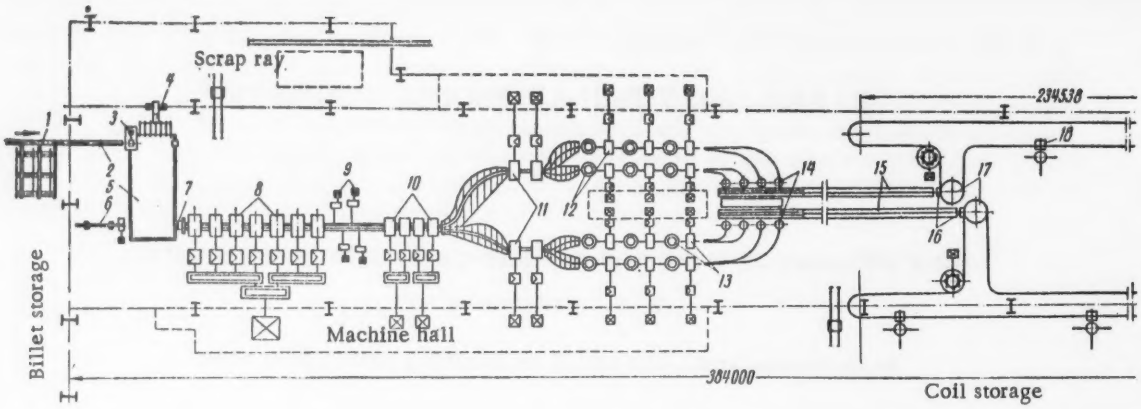


Fig. 1. Layout of the wire mill: 1) charging grate; 2) front roller table; 3) charger; 4) pusher; 5) heating furnace; 6) discharging pusher; 7) pulling-out and distributing apparatus; 8) roughing group; 9) emergency flying shears; 10) first intermediate group; 11) second intermediate group; 12) left finishing group; 13) right finishing group; 14) coilers; 15) muffled conveyer; 16) coil-hanging apparatus; 17) hook conveyer; 18) coil-removing apparatus.

screws by means of a lever with a nonreturn pawl. One turn of the handwheel is equivalent to one step of the screw-down screw, i.e., 0.5 mm.

The upper roll is counterbalanced by means of a set of disc springs, mounted on the bearing blocks of the lower roll.

For the adjustment of the passes in the line of rolling, the horizontal stands can be moved on the base plate at a speed of about 10 mm/sec by an electric motor of 4.2 kw via a conical gear. The working rolls are connected to the main drive by a universal spindle, pinions and distributing gears.

Each stand is equipped with cooling spray device positioned in front and at the back of the stand on the upper and the lower roll.

Between the roughing and the first intermediate groups there are flying shears for cropping the front ends and for cutting the billets into 1890 mm long pieces (in the case of a breakdown at the stands behind the roughing group). The shears on the first and second line are of left-hand action, on the third and fourth of right-hand action. The maximum cross section which can be cut is 289 sq m and the maximum cutting force is 4600 kg.

All remaining horizontal stands are similar to those of the roughing group.

The second intermediate group consists of two horizontal stands with separate drives. There are two intermediate groups: the left and the right; in each group the rolling is carried out in two lines.

In front of the second intermediate group, there are shearing knives, one for each line. The maximum cross section which can be cut is 12 x 12 mm, the temperature of the metal is 1000 °C, the tensile strength of the material rolled at 1000°C is 10 kg/sq mm, and the width of the cut is 34 mm.

The finishing stands of the mill consists of four groups, each group comprising one rolling line. The finishing group consists of three vertical and three horizontal stands arranged alternately. The vertical stands have open-type housings. The motor and reducing gear are situated above the housing. The rolls are mounted on roller bearings, type GPZ-130 and 32130, in special replaceable frames. When the change over from one pass to another is made, the vertical displacement of the rolls is effected by means of a mechanism consisting of lead screws and worm gears driven by a 4.2 kw electric motor. The rolls are set by means of a screw-down mechanism, operated by a hand wheel; one turn of the wheel is equivalent to the displacement of the adjusting screw through 0.4 mm. The displacement of the rolls from the axis is equal to 30 mm, the axial displacement of one roll in the housing is ± 3 mm, the vertical adjustment of rolls is + 200 and -389 mm, the speed of vertical movement of the housing is 2.9 mm /sec.

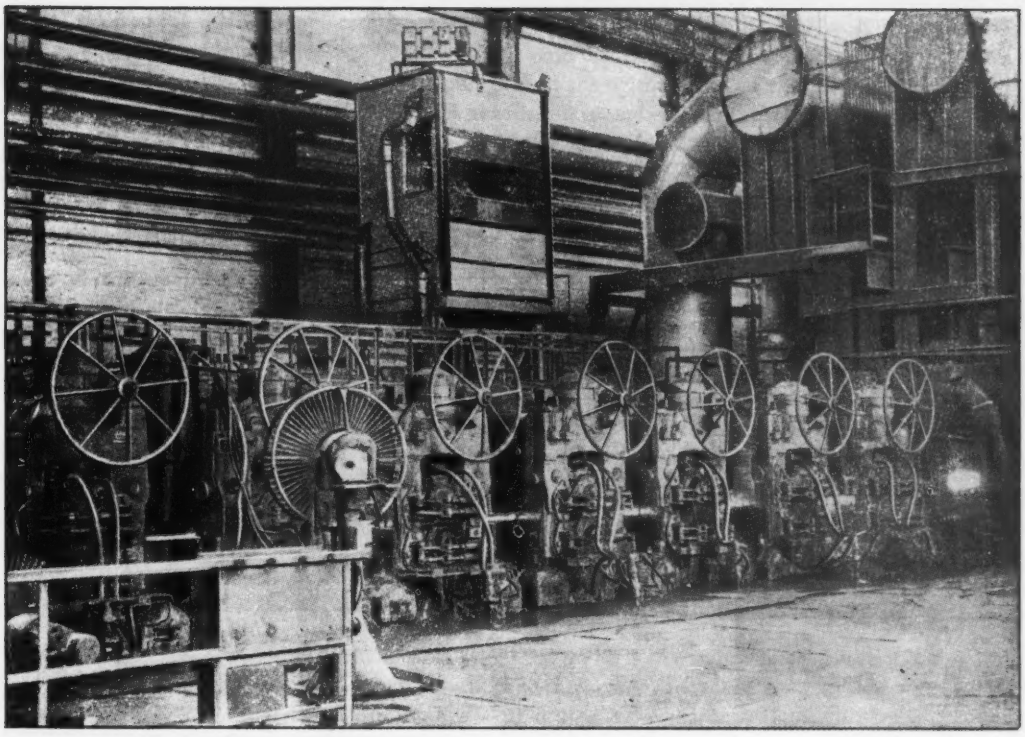


Fig. 2. Roughing group of stands

The change of vertical stands is carried out by interchanging the replaceable frame by means of a rolling-out device. The length of the path is 12.5 m, the speed 15.7 mm/sec.

Between the first and the second intermediate groups, as well as between the second intermediate and the finishing group, there are guide tables for supporting the loops formed during the rolling.

Eight reels with rotating cones are placed behind the finishing groups. For each line, there are two coilers on which the wire rod is wound into coils of 850-900 mm internal diameter and 1150-1200 mm outer diameter. The coilers operate automatically; the speed of cone rotation corresponds to the speed of the last stand of the finishing group. The reel has a hollow shaft mounted on roller bearings. The shaft is driven by a 6.1 kw, 500-1500 rpm electric motor. The cone is fixed to the end of the shaft and rotates with it.

Wire from the last stand of the mill passes through a tube inside the hollow shaft and goes to the cone which lays it into a coil. The finished coil is pushed from under the cone onto the muffled conveyer by means of a pusher. The speed of coiling is 12.37-30.00 m/sec.

The muffled conveyer for the retarded cooling of coils and their transportation to the hook conveyer is situated in front and along the left and right groups of reels. The length of the left muffled conveyer is 89.827 m, of the right one 92.627 m; its velocity is 0.043-0.075 m/sec. By means of a mechanism at the end of the muffled conveyer, the coils are placed on the hook conveyer.

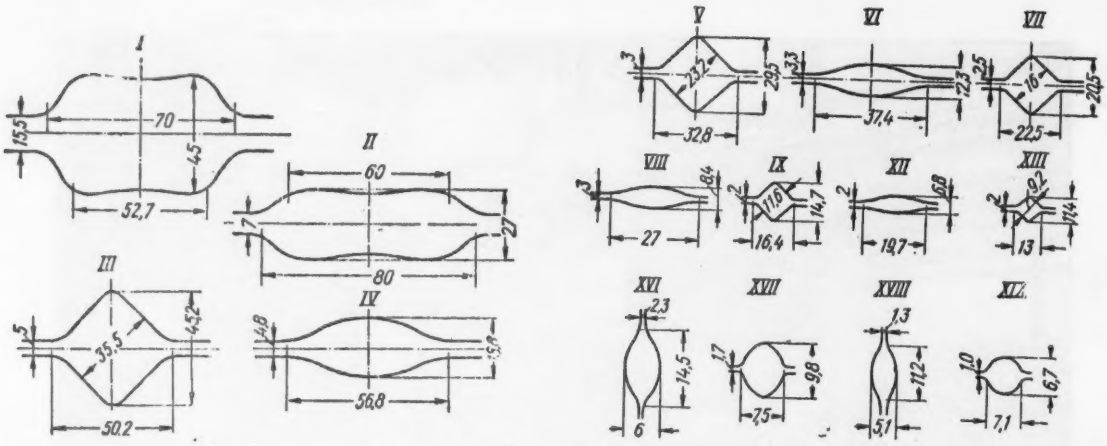


Fig. 3. Arrangement of passes for rolling wire rod 6.5 mm in diameter: I-VII stands of the roughing group; VIII-IX stands of the first intermediate group; XII-XIII stands of the second intermediate group; XVI-XIX stands of the finishing group.

Operating Conditions for Rolling Wire Rod 6.5 mm in Diameter

Group	Stand No.	Type of pass	Dimensions of rolled piece, mm				Cross-sectional area mm²	Draft coefficient	Reduction, mm	Spread, mm	Rolling diameter, mm	Speed of rolls, rpm
			height	width	Side of square	length						
Roughing	0	Initial billet	60	60		12 000	3600					
	1	Box	45,5	66		15 600	2760	1,3	15,5	5	394	14,6
	2	Flat oval	27	76,5		23 700	1820	1,52	18,5	10,5	428	20,5
	3	Square	45,2	45,2	35,5	35 000	1230	1,48	31,3	21,2	397	32,6
	4	Oval	18,8	56		55 500	775	1,58	16,7	20,5	405	50,6
	5	Square	29,5	29,5		80 150	526	1,47	26,5	11,4	354	85,4
	6	Oval	12,3	35,5		125 000	342	1,54	11	12,3	364	128
	7	Square	20,5	20	16	173 000	248	1,38	15	7,7	360	179
First intermediate	8	Oval	8,4	26		244 000	176	1,41	7,6	10	316	288
	9	Square	14,7	14,4	11,6	330 000	131	1,35	11,3	6	312	395
	10	—	—	—	—	—	—	—	—	—	—	—
	11	—	—	—	—	—	—	—	—	—	—	—
Second intermediate	12	Oval	6,8	19		428 000	101	1,3	4,8	7,4	316	505
	13	Square	11,4	11	9,2	536 000	81	1,25	7,6	4,2	314	640
Finishing	14	—	—	—	—	—	—	—	—	—	—	—
	15	—	—	—	—	—	—	—	—	—	—	—
	16	Vertical oval	13,5	6		670 000	65	1,25	3,2	4,3	267	935
	17	Horizontal oval	9,8	7,3		870 000	49,8	1,3	3,7	1	264	1240
	18	Vertical oval	10,2	5,1		1 050 000	40,8	1,22	4,7	0,3	267	1500
	19	Circular	6,7	6,7		1 230 000	35,2	1,16	3,5	1,6	265	1760

Total draft $\Sigma\mu = \frac{3600}{35} = 103$

Mean draft $\mu_{cp} = \sqrt[15]{103} = 1,36$

Speed of rolling in stand № 19, m/sec 24,5

Time of rolling, sec:

actual rolling	51,5
breads	4
total	55,5

Output, tons/hr 85

The left hook conveyer is 234.5 mm long and has 278 hooks, the right one is 235.7 m long and has 280 hooks. The weight of the material carried by one conveyer is about 90 tons, the speed of transportation is 0.043-0.075 m/sec, and the total distance of the transportation is 500-505 m. Both hook conveyers have attachments for removing the coils from the hooks and placing them onto the spokes of the packing machine, and also three packing machines for each conveyer; the main part of the packing machine is a revolving head with four carrying spokes. When one spoke is loaded with coils, the head is turned and another spoke is set in position. Each spoke can take up to 8 coils which are lifted from it by a swing crane of 5-ton load-lifting capacity (by means of a special C-shaped hook) and are placed in a basket or loaded into cars.

The roll-changing of the horizontal stands is carried out, as a rule, by means of complete spare stands, and of vertical stands by means of interchangeable frames assembled and adjusted beforehand on special stands.

Some difficulties were encountered, when the mill was being put into operation, in connection with design defects in some parts of mechanism. The personnel of the plant redesigned the following parts: the bar of the discharge pusher of billets, the pulling-out and distributing apparatus, the lifting troughs at the emergency shears, the guides to the reels, the reels, and the control and adjustment system of the speed of the working rolls of the finishing groups. At present, improvements are being carried out on the coil-hanging and coil-removing equipment, the packing machines, the spindle unit of the finishing stands, and other parts.

At the time when the mill was put into operation, the pass design and the roll accessories were improved and the arrangement of passes was modified. Now, wire rod 6.5 mm in diameter is rolled in the finishing group not in six passes, as it was initially, but in only four passes. This makes it possible to maintain a more constant cross section, to facilitate the control of the speed of rotation and to decrease the stretching of the rod between the stands. The operating conditions for rolling this wire rod are given in the Table, and the arrangement of passes in Fig. 3.

In the horizontal stands of the roughing, as well as of the first and second intermediate group, all oval sections are turned through 90° and the square sections through 45° by means of spiral guides. Specially prepared tubes, 32 × 4 and 28 × 4 mm, are used as delivery guides in the 9th, 13th, 16th, 17th, 18th and 19th stands.

Special inserts with a set of passes, which require very little time for interchanging, are used as receiving guides for the 12th, 13th, 17th and 19th stands. The passes for the inserts are ground and assembled with the use of a special template in the guide workshop. The remaining horizontal stands have receiving guides with vertical separation and the second stand and all vertical stands have receiving guides with horizontal separation. All guide equipment is made of 35-45 cast steel, and the entry passes for the 12th, 13th, 17th and 19th stands are made of cast iron.

For the period of operation from January to August, 1958 the consumption per one ton of useful product was as follows:

Electric power, kw-hrs	80
Water cu m	27
Steel, tons	1,066

The design capacity of the mill is 500,000 tons per year.

REDUCING QUENCHING CRACK DEFECTS

P. P. Zuev

Head of Steel-Rolling Plant No. 1 of the "Electrostal" Works

A large number of steel grades produced at our Works exhibit a tendency to quenching crack formation. To this number belong mainly the steels of perlite-martensite and martensite types: 3Kh13, 4Kh13, R9, R18, I347, KhVG, Kh10S2M, Kh9S2, Kh12, Kh12M and other steels.

Quenching cracks are caused by structural transformations in steel. When rolled steel is rapidly cooled, there is no time for the transformation of austenite in the temperature range of perlite transformation, and so martensite structure is formed; the transformation of austenite into martensite is accompanied by a substantial increase in volume and the appearance of great stresses.

When the magnitude of stresses exceeds the ultimate tensile strength of steel the disruption of material (the occurrence of cracks) takes place. Fine quenching cracks are diverse in their outward appearance: they may form a broken line or be scattered over the whole surface area of the piece.

Fig. 1 shows two rolled steel pieces affected by quenching cracks.

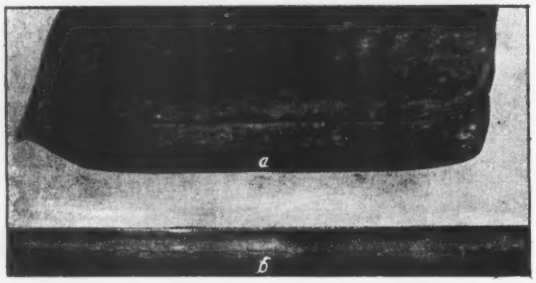


Fig. 1. Quenching cracks:
a) on R9 rolled square section; b) on 3 x 13 steel rod.

In order to prevent the occurrence of cracks one must, first of all, cool the metal slowly. This helps in reducing structural stresses.

At the "Electrostal" Works, a slow cooling of metal from 700-900°C is carried out in unfired or fuel-oil-fired pits, or in thermostats.

The unfired pits are rectangular pits lined with refractory brick. The walls of the pits are faced with steel plates, rails or square bars. From above they are covered with double-plate metallic lids insulated with slag wool.

The heated pits differ from the unfired ones only in that they have a flue and chimney, and are fitted with burners. The thermostats (Fig. 2) are boxes with double-walled sides, bottom and lid, the space between the two walls being filled with slag wool.

Round and square (70-100 mm) sections from the 600 mill are cooled in unfired pits; coiled steel products mainly are cooled in heated pits, and sections rolled on the 300 mill (rounds and squares 8-55 mm) are cooled in thermostats.

When the defects due to quenching cracks were investigated, it was established that they occur mainly on coiled steel of grades R9 and R18 cooled in fired pits, and on bars of steel grades 3Kh13, 4Kh13, Kh10S2M cooled in thermostats. Cracks formed because the cooling of the steel was not sufficiently slow.

The regime of cooling in fired pits was as follows: a) the pits were heated for 8 hours prior to charging the coils; b) temperature in the pits at the commencement of charging was not less than 600-650°C; c) temperature of coils when charged into the pits was 500-600°C; d) after the charging was finished the lids were placed tightly in position and any gaps were filled with slag wool; e) in order to achieve a uniform temperature, the pit with the coils was heated at 700-750°C for three hours; f) the cooling of metal in the pits took at least 24 hrs; g) coils were removed from the pits at a temperature not above 50-100°C.

The cooling regime for coils was studied on 9 mm diameter steel bars of R9 steel.

The check on the operating conditions showed that the existing design of the pits does not ensure the necessary temperature of the bottom and the middle of the pit for preventing the formation of quenching cracks.

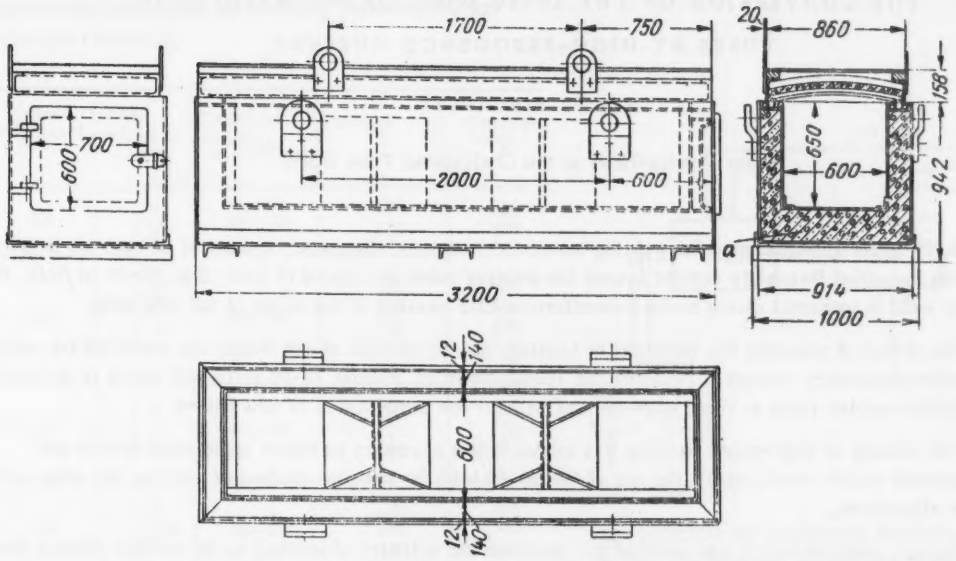


Fig. 2. Thermostat for cooling steel sections of 8.10 and 12 mm diameter; a) slag wool.

Therefore, the pits were equipped with additional burners and a chimney, and the following optimum cooling regime was established: a) heating the pits for 6 hours prior to charging. During the last 3 hours, the temperature of heating should be at least 850°C; b) the temperature of the coils at charging should be at least 500-600°C; c) the temperature in the pit during the charging of the coils should be lowered to 700°C; d) after the coils have been charged and the lid has been replaced, the temperature in the pit should be increased to 800°C and the coils should be kept for 3 hours; e) in the case of coils of Kh9S2 grade steel, the burners may be turned off after the coils have been charged; f) for speeding up the cooling, the lids of the pits may be removed (at a temperature below 400°C). As a result of the introduction of the new method, the defects due to quenching cracks on coiled product of R9 and R18 steel were eliminated. The new method was tested also for 8-12 mm diameter bars of 3Kh13 and 4Kh13 steels cooled in thermostats.

After they have been rolled and cut with transportable shears, situated directly at the finishing stand of the mill, the bars are placed in the ordinary heated thermostat and when it is filled they are transferred to the heated pit.

The bars are cooled in the same way as the coils.

The bars (circular and square, 8-55 mm) of R9 and R 18 steel grade are cooled in thermostats according to the following regime: a) the bars are charged into the thermostat at a temperature of not less than 650°C; b) the length of cooling time is not less than 24 hrs, c) the metal is removed from the thermostat at a temperature of not more than 100°C; d) the bars are transported to the heat-treatment plant for annealing not later than 12 hrs after discharge from the thermostat; e) the bars are charged into the furnace of the heat-treatment plant not later than 16-24 hrs after it has been received at the plant.

This method makes it possible to obtain product free from quenching cracks.

The rolled products from the 600 mill are cooled in unfired pits according to the following regime: a) the temperature of steel at the end of rolling process is not less than 900°C; b) the material in batches of 2-3 tons is charged into the pit at a temperature of not less than 700°C; c) the duration of cooling is at least 30 hours; d) the material is taken out at a temperature of not more than 150°C.

Products of 3Kh13 and 4Kh13 steel grades, intended for rolling on the light-section mill because they are most prone to quenching cracks, are annealed at the heat-treatment plant after their discharge from the pits.

After the methods of cooling described above have been adopted, the heating pits permit the thermal treatment of steels which have a tendency to quenching-crack formation.

THE CONVERSION OF THE 10-60 MILL TO THE WELDING OF TUBES BY HIGH-FREQUENCY CURRENT

Iu. A. Mednikov

Plant Deputy-Head at the Cheliabinsk Tube Works

The 10-60 mills were designed for welding tubes with industrial-frequency current of 50 cps. As is known, however, when industrial frequency current is used for welding tubes at a speed of more than 25-30 m/min, the quality of the weld is impaired owing to the nonuniform cyclic heating of the edges of the tube strip.

With the object of reducing the variation in heating, the 10-60 mill at our Works was modified for welding tubes with higher-frequency current. In addition, the reequipment of similar 10-60 mills will result in an increased output of electric-welded tubes at small expense and without the introduction of new plants.

When the change to high-speed welding was made, it was necessary to select appropriate speeds and current frequencies which would permit the use of the 10-60 mill for the new method of welding the tubes without extensive alterations.

Calculations showed that it was possible to increase the velocity of welding to 40 m/min without the need for replacing the pinions and transmission of the main motor. The existing equipment for cutting the tubes could also be used at that velocity.

At the same time, it was found desirable to select a frequency of 100-150 cps. These data constituted the basis for the design of a higher-frequency changer system.

Two possibilities of changer operation were investigated; operation at 150 cps and at 100 cps.

Initially, it was planned to use asynchronous frequency changer (APCh) for the 10-60 mill. The APCh system (Fig. 1) consists of a higher-frequency generator (APCh), an asynchronous motor, a coarse-control 300 kw autotransformer and a fine-control 300 kw autotransformer.

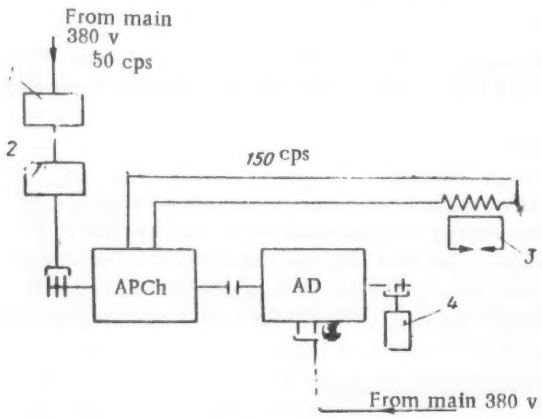


Fig. 1. Circuit of asynchronous higher-frequency changer (APCh):
1) fine-control autotransformer; 2) coarse-control autotransformer; 3) welding transformer; 4) starting resistance.

In the asynchronous frequency changer, the high frequency generator's rotor is excited by a three-phase current through two transformers, one of coarse and the other of fine control.

In the synchronous system the rotor is excited by a direct current of 8-12 v. For this, one needs a relatively small-capacity generator of 10 kw. The synchronous frequency changer (Fig. 2) consists of a high-frequency generator an asynchronous motor and an excitation generator of 10 kw.

Thus, by changing to the synchronous system, one eliminates two units: the coarse-control and fine-control transformers. The remaining machines are the same. Therefore, the second method, involving the synchronous frequency changer, was chosen.

The test welding of tubes with the use of an asynchronous frequency changer showed that it was necessary to reinforce the pinions, intensify the cooling of the revolving transformer TV-200 and to intensify the cooling of the emulsion.

Operating Conditions for Welding Tubes at 100 cps Current Frequency

Tube diameter mm	Wall thickness, mm	Speed of welding, m/min	Voltage	Current, amp
12	1,0 1,25	38—40	100 110	400 500
22	1,25 1,5 1,75 2	36—38	100 120 120 130	600 700 800 900
33	1,5 1,75 2	36—38	120 130 140	800 900 1000
36	1,5 1,75 2	36—38	120 130 140	800 900 1000
40	1,5 1,75	36—38	130 140	800 900

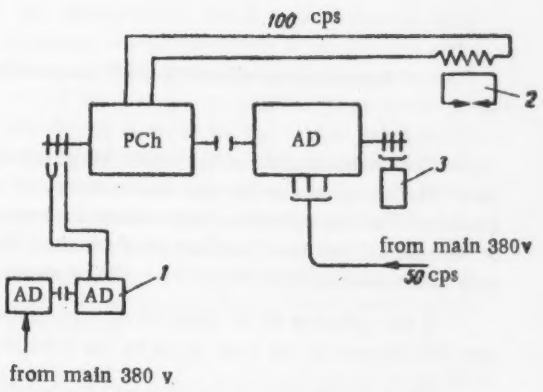


Fig. 2. Circuit of synchronous frequency changer (PCh). 1) exciter; 2) welding transformer; 3) starting resistance.

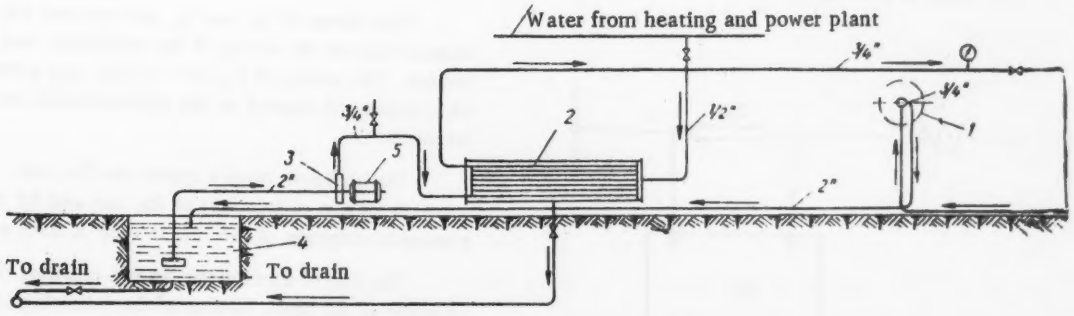


Fig. 3. Cooling system of the revolving transformer TV-200: 1) revolving transformer; 2) water cooler; 3) centrifugal pump; 4) supply tank for distilled water ; 5) electric motor.

It was planned to reinforce the pinions by increasing the area of the bearings and to intensify the cooling by fitting an additional cooling coil in the tank. The revolving transformer TV-200 was provided with a closed-cycle forced cooling system as shown in Fig. 3.

After the mill was reequipped, test weldings of tubes under various operating conditions were carried out and, as a result, definite operating conditions were recommended (see Table).

All tubes which were welded under these conditions were found satisfactory.

By operating at a higher current frequency on the 10-60 mill, it was possible to increase output per worker by 14.2% , and to reduce steel consumption by 2.3%. Maximum output per shift reached 20,090 m of tubes.

A further increase in the output of the mill is impaired by the inadequate capacity of pinions and the small capacity of the TV-200 transformer, in particular for welding tubes of 2 mm or larger wall thickness.

AUTOMATIC CONTROL OF STRIP FRACTURE ON ELECTROLYTIC ANODIC CLEANING

V. V. Kozhevnikov

Section Head at the Plant KIP Automation at the Magnitogorsk Metallurgical Combine

The tin-plate plant at the MMK (Magnitogorsk Metallurgical Combine) has an electrolytic anodic cleaning line. The design of the line and the conditions of strip preparation do not eliminate the probability of strip fracture. The fracture of the strip entails a stoppage of the line for 20 min to 1.5-2.0 hrs. The greater the speed of the line and the later the fracture is detected, the greater will be the distance between the ends of the fractured strip and consequently a longer time will be necessary for putting the line into operation again.

If the variation of the speed of the strip is disregarded the distance between the separate parts of the broken strip will depend on the time taken for the machine to be stopped.

The stopping time of the line may be expressed by the formula:

$$\tau_{stop} = \tau_1 + \tau_2 + \tau_3 + \tau_4 \text{ sec.}$$

where

τ_1 – time from the moment of fracture to the moment when it is detected;

τ_2 – time necessary for the operator to press the emergency button;

τ_3 – time of the operation of the equipment;

τ_4 – time of braking the line.

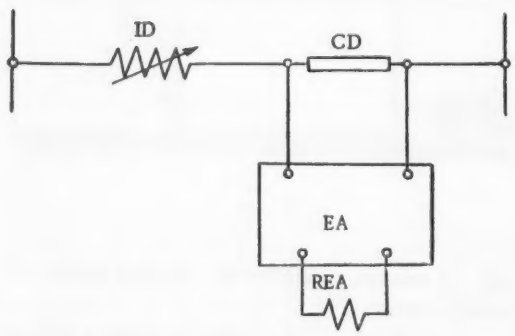


Fig. 1. Circuit diagram of the induction pickup; ID) induction pickup; CD) range multiplier; EA) electronic amplifier; REA) relay of electronic amplifier .

The values of τ_3 and τ_4 are constant and depend only on the setting of the equipment and the motors. The values of τ_1 and τ_2 may vary within wide limits and depend on the operators skill and attention.

The author devised a system for the automatic detection of fractures of the line and for the automatic stoppage of the line in case of fracture.

The line of electrolytic anodic cleaning of tin plate at the MMK consists of the following units: a decoiler, No. 1 entry roll, a shear for cutting the strip ends, a welding machine, No. 2 entry rolls, No. 1 rinsing machine, No. 1 bath, No. 2 rinsing machine, No. 1 driving rolls, No. 2 bath, No. 3 rinsing machine, drying unit, No. 2 driving rolls, No. 3 driving rolls, a shear for cutting the weld, and a coiler.

The strip is subjected to tension on two sections of the line: between the decoiler and the No. 1 driving rolls, and between the No. 1 driving rolls and the No. 2 driving rolls.

In the course of the operation of the line, it was found that the largest number of fractures occur in the rinsing machines and the baths.

For the detection of the strip fracture, we used the induction pickup of IKV-10 type made by the "Elektroprivod", and an electronic amplifier. The pickups are placed above the strip: behind the No. 1 and No. 2 rinsing machines and behind the No. 1 driving rolls.

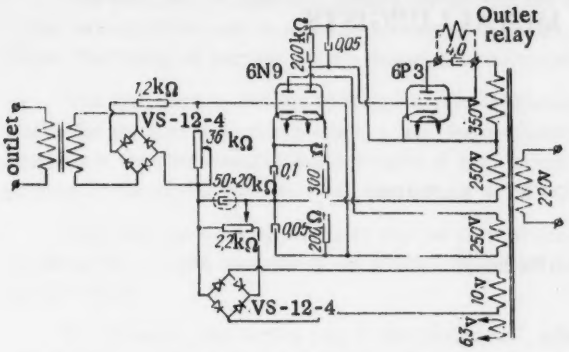


Fig. 2. Circuit diagram of the electronic amplifier.

When the line is in operation, the gap between the strip and the pickup is 30 mm and this corresponds to a current of 0.65 amp in the coil of the pickup.

Owing to the loss in tension when the strip is broken, the gap increases to 90-100 mm and this corresponds to a current of 0.8 amp in the coil of the pickup. A circuit diagram of the induction pickup is shown in Fig. 1. The range multiplier in the coil of the pickup is equal to 10 ohm. Voltage drop from this resistance is taken to the input of the electronic amplifier whose circuit diagram is shown in Fig. 2. When the strip is fractured, the electronic amplifiers, to whose terminals are connected electromagnetic relays, are operated.

Electromagnetic relays actuate the switch-off contactor which switches off the line contactors of the No. 1 and No. 2 driving rolls and also commands the switching off of the line contactor of the generator. The automatic strip fracture control system is switched on automatically every time when the line is started and is switched off when the line is stopped.

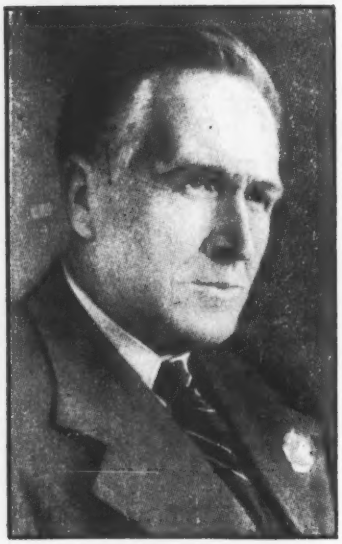
A control key on the operator's control desk is included in the automation scheme.

As a result of the automation of strip-fracture control, the stoppages of the line were reduced by more than half and the work of the operators became much easier.

OUTSTANDING METALLURGISTS

IVAN PAVLOVICH BARDIN

(on his 75th Birthday)



Ivan Pavlovich Bardin is one of our prominent men, renowned far beyond our country. Many years of his fruitful scientific, political and social work have been closely linked with the development of Soviet metallurgy.

Ivan Pavlovich was born in 1883 into a peasant family living in the Saratov province. He obtained his primary education in the village school and the town school, and then attended an agricultural school which he left in 1903, to enter the Novo-Aleksandrovskaia Agricultural Institute. Very soon I. P. Bardin was expelled from the Institute for his political views but this did not prevent his perseverance in acquiring knowledge.

In 1906, Ivan Pavlovich entered the Agricultural Department of the Kiev Polytechnical Institute. He soon changed to the Chemistry Department and graduated as an engineer-technologist in 1910.

His knowledge of the metallurgy of iron and steel was acquired under the supervision of Prof. V. I. Izhevskii, the author of the design of an original electric furnace; Ivan Pavlovich was engaged on testing this furnace at the Briansk Works.

A good theoretical training, however, did not ensure employment in his special field. In addition, his position was rather difficult, owing to the fact that he was once expelled from an institute for his political views. All this prompted the young engineer to seek good fortune in the USA "the country of liberty". His attempts were unsuccessful; after a short spell of work at the Gary works, Ivan Pavlovich had to leave the job because of ill health.

After his return from the USA, I. P. Bardin joined the technical bureau of the Yuzovka Works where he met the prominent Russian metallurgist, M. K. Kurako.

Spiritual friendship with Kurako enhanced the resolution, inherent in the nature of Ivan Pavlovich, to introduce new techniques into production processes. This friendship continued at the Enakievko Works to which they both came from the Yuzovka works and where Ivan Pavlovich was appointed head of the blast-furnace plant, in 1915, and later chief engineer.

The October Revolution provided conditions for a creative development of national potentialities and unlimited scope for the application of these potentialities in socialist economy. The successes of the Soviet people are shown by an increase in pig iron and steel output by a factor of 9 to 12 as compared with the highest output in pre-Revolutionary Russia.

This rate of the development of the iron and steel industry, unprecedented in world history, and brought about under the guidance of the Communist Party, is closely connected with the creative enthusiasm of our leading innovators, outstanding men who dedicate their knowledge, experience and effort to our dear industry.

The work of I. P. Bardin is closely linked with the achievements of our iron and steel industry. Even in the initial period of his work at works in the South(Enakievo, Makeevka and Dzerzhinskii Works), his creative talent, his clarity of purpose and his devotion to technical inventiveness manifested themselves.

The construction and the introduction into operation of the 100-ton open-hearth furnace at the Dzerzhinskii Works, for the first time in our country, and the mechanization of blast furnaces at iron and steel works in the South were the first creative achievements of I. P. Bardin on the long and glorious road in the fight for technical progress in the Soviet iron and steel industry.

The task, assigned by the Party and the Government, of developing,first and foremost,heavy industry and, in particular, a rapid increase in the productive capacity of the iron and steel industry was the basis of all I. P. Bardin's work.

On taking a most active part in the design and, subsequently, in the construction of large iron and steel works, Ivan Pavlovich eliminated all mediocre and conventional methods, which were still accepted even in developed capitalist countries, and consistently realized the idea of building large industrial establishments on the basis of most advanced production methods and equipped in the most modern manner.

With the use of the most advanced and progressive ideas which were contained in the projects by foreign firms, an original and basically new design of an integrated iron and steel works was drawn up, and Ivan Pavlovich put it into practice in the construction of the Kuznetsk Metallurgical Combine.

After the completion of construction, I. P. Bardin was transferred to the People's Commissariat of Heavy Industry, where, from 1938 onwards he was the Chairman of the Technical Council and, later on, a Deputy People's Commissar.

In 1932, I. P. Bardin was elected a member of the Academy of Sciences, USSR, and, since 1942, he has been a Vice-President of the Academy.

During the Patriotic War, I P. Bardin, who was one of the leaders of the Commission of the Academy of Sciences, USSR, for the mobilization of the resources of Eastern regions for defense needs, showed boundless energy and great effort in carrying out the assigned task. The Government valued very highly the services of I. P. Bardin and his group of collaborators, and awarded them the Ist Grade Stalin Prize for the work they had done.

Attaching great importance to an organic link between science and industry, to scientific assistance in the rationalization of methods and inventiveness, and to the introduction of all new and advanced techniques into production, I. P. Bardin initiated the establishment of the Central Scientific Research Institute of Ferrous Metallurgy and has been the head of the Institute ever since 1944.

At the same time, I. P. Bardin is the Director of the Institute of Metallurgy of the Acad. Sci., USSR, and the Chairman of the Urals Branch of the Acad. Sci., USSR.

The scientific guidance of I. P. Bardin in those institutes is aimed at solving the basic problems of the iron and steel industry: an improvement in the preparation of raw materials, an increase in the capacity and output of blast furnaces, improvements in the design of open-hearth furnaces and a better utilization of heat in open-hearth furnaces. Ivan Pavlovich pays special attention to the investigations connected with the adoption of basically new processes in industrial practice. In particular, for the introduction of the method of intensifying the open-hearth process by means of oxygen, I. P. Bardin was awarded the Ist Grade Stalin Prize for the second time.

Under the direct leadership of I. P. Bardin, very important investigations on the continuous casting of steel and the production of pig iron outside the blast furnace are being carried out, and a great scientific work on the establishment of a modern theory of metallic oxide reduction is under way.

In 1947, on the initiative of I. P. Bardin, the Permanent Joint Commission for Iron, which coordinates all work on the study and technical and economic evaluation of iron ore resources in the USSR was constituted. Taking great interest in the discovery of new ore resources of the USSR, I. P. Bardin enlists the cooperation not only of specialists from research and design institutes, ministries, departments and governing organizations but also of the National Economic Councils of the Economic Regions, and he attaches great importance to everyday cooperation with the Councils.

Side by side with his great work in the field of scientific research, I. P. Bardin at the same time shoulders enormous social and political work. Since his election to membership of TSIK* USSR in 1934, Ivan Pavlovich has been repeatedly elected a Deputy to the Supreme Soviet of the USSR; at present, he is the Deputy to the Supreme Council of the USSR from the Kemerovo province.

Many Government awards to I. P. Bardin show how his scientific and political work is highly appreciated by the Party and the Government. He has seven Lenin Orders; in 1942, I. P. Bardin was awarded the title of Hero of Socialist Labor. In April of this year, I. P. Bardin and a group of workers were awarded the Lenin Prize for the development of a commercial plant for the continuous casting of steel.

Soviet metallurgists and our whole nation sent heartfelt greetings to Ivan Pavlovich Bardin on his 75th birthday and sincerely wish him many happy returns, good health and creative scientific work.

I. S. Shapiro.

*Central Executive Committee. – Publisher's note.

GENERAL ARTICLES

ORGANIZATION OF PRODUCTION QUALITY CONTROL

In the article by N. P. Inozemtsev, Ia. I. Sokol and S. I. Zamiatin, "Organization of Production Quality Control", published in the Metallurgist No. 9, 1957, the question of reducing the OTK (Department of Technical Control) staff and increasing the responsibilities of plant personnel with regard to the quality of production was raised. There are some comments in this article.

I. A. Dvorchik

Head of the Department of Technical Control of the Cheliabinsk Tube Works

At present, some of the OTK functions specified in the Technical Control Regulations, which were approved earlier on, should be transferred to the production personnel. These functions include the control on the maintenance of operational conditions and schedules of production as well as the post-operational control.

In the steel-making plant, the OTK control on furnace charging, steel smelting, preparation of ladles and steel pouring should be abolished.

At the Cheliabinsk Tube Works, since July, 1956, the OTK control on the technology of furnace charging and on steel smelting at the steelmaking plant has been abolished. The number of shift-control foremen and furnace-bay controllers has been reduced. The heat books are, therefore, filled in by plant foremen. The OTK retained the control on the preparation of pouring spouts and on steel pouring. In addition, the OTK workers in the casting bay mark the height of the ordered ingots on the molds and check the labels on the molds carefully. After the steel has been poured, they remove the labels from the molds which were not filled, measure the time of filling the mold with a stopwatch, take and mark samples from each heat for chemical analysis, deliver the samples to the laboratory, watch that ingots from different heats do not get mixed up, mark the heat number on the side of the ingot and prepare the report on the pouring.

We consider that the control of all the above operations should be passed to the production personnel (the weight of steel accepted is determined by the OTK markers when the ingots are transferred to the tube-rolling plant).

There is no justification for the opinion of the "Elektrostal" Works management, (Metallurgist No. 4, 1958) who retained the OTK control on the charging and the smelting and pouring of metal in the steelmaking plant, where the amount of defective production was still high. But the amount of defective product remained high. It follows that the control of the technological process alone, without carrying out some other measures, will not eliminate defective products. The leaders of those plants, the technical departments and the Central Works Laboratory do not know the actual causes of the high percentage of defective material and the operating conditions which have not been fully established will always result in a high percentage of defective product. With incorrect operating conditions, the control on maintaining these conditions will have negative results if the operating conditions are not put right in time. In order to reduce the percentage of defective product, one should revise the technological instructions which have not been properly worked out, rather than maintain the status quo.

For a long time, at our steelmaking plant which produces round ingots, it was not possible to reduce the amount of defective product, due to longitudinal cracks, to less than 1.5 %. However, in spite of careful attention to this problem, it was only in December, 1956, when the speed of steel pouring was decreased by about 15%, that the percentage of defective products due to longitudinal cracks was reduced by half.

The tube-rolling mills are not adjusted automatically according to the results of the determination of the cross-sectional dimensions of the rolled material, and the measurements themselves are not automated (the measurements are made by hand after the mills operation). Correct operating conditions of a tube-rolling unit are maintained by a continuous or regular check of the dimensions of rolled material. Therefore, the personnel engaged on measurements should be on the production foreman's staff. The plant should have on its staff the "primary inspection"personnel engaged on marking tube parts which have to be reconditioned or cut owing to defects.

It is necessary to abolish OTK control on the storage of raw and other materials and to transfer these duties to the management of the stores of the technical supply department. The OTK controls the quality of packing materials, the packing of finished product, the preparation of means of transportation and the storage of finished product; the responsibility for carrying out these operations should be put on shift team leaders, dispatch foremen and foremen of sections where the product is packed and dispatched from the plant.

Since 1956, at the Cheliabinsk Tube Works, the finished product at the No. 2 tube plant is delivered from the plant without OTK control (except for tubes on export orders). At the electric tube-welding plant, an OTK worker present at the dispatch of tubes records the "dispatch" data relating to the finished tubes, and at the Mannesmaun plant an OTK workers supervises the dispatch. The inventory of the product dispatched is made by the dispatch personnel.

Neither is the external acceptance inspection by the OTK personnel justified. The control on the quality of goods (raw and other materials and fuel) received by the works should be abolished, since the OTK personnel of the establishment which supplies the goods are better qualified for this work. They have a better knowledge of the processes and operations of the particular production, of weak spots with regard to quality, and they have better facilities for inspection (floors, cranes, etc) than at the consumer's receiving department.

We cannot agree with the Lenin Dnepropetrovsk Tube Works (Metallurgist No. 3, 1958,page 34), which has abolished the posts of controllers on the inspection of molds and refractories, and transferred their duties to the controllers on the inspection of raw materials. The inspection of refractories may consist of visual inspection, taking samples and carrying out certain tests.

During the moving of refractory bricks for inspection (if one can imagine such an operation at the receiving works), considerable losses are liable to occur. A second inspection control of refractories cannot be justified. Neither is there need for mold inspection after the molds have been accepted by the OTK at the works supplying the goods.

There has been no inspection of auxiliary materials delivered to the main storage and to the open stores at the Cheliabinsk Tube Works.

Some provisions of the "Basic Conditions for the Delivery of Metal and Metal Products", where it is stated that "within 10 days of the delivery of the goods at their destination... the recipient has to carry out a thorough check to see if the goods received are within the standard specifications and technical conditions and correct according to accompanying certificates"should be revised. Such a requirement entails worthless work which, for the most part, simply cannot be carried out. For instance, the electric-welding plant of the Cheliabinsk Tube Works receives about 1300 tons of steel plate daily. How can one "carry out a thorough check if the goods received are within the standard specifications ?" What crane equipment and floor space would one require?

The same position with regard to checking goods applies at other plants. "External acceptance inspection" also involves making out complaint documents regarding any substandard goods according to the initial data on products which the OTK sections at the production plants consider defective. The making out of complaint documents should be transferred to claim(legal) departments existing at every works.

The requirements with regard to completing the forms relating to defective products must be revised so that the document can be made out with the use of the certificates which are issued by the supplier of the goods and are held by the OTK.

When the "external acceptance" is abolished, the "final acceptance" should be better organized and modern equipment and instruments should be provided. The responsibility of the works for the supply of substandard products should be extended: fines for supplying substandard products should be increased to the value of the rejected products. Establishments should have a financial responsibility for failing to present claims regarding the supply of defective material.

When the problem of grading and sorting metal, raised by the employees of the "Serp i molot" Works, has to be solved one should bear in mind a possible minimum time required for sorting the tubes.

At the Cheliabinsk Tube Works, this problem is solved at different plants in different ways, depending on the specific conditions of inspection. At the 10-60 mill, the OTK workers themselves grade tubes into three receivers: for good tubes, for rejects and for tubes which require conditioning. The main operation on this section is the check of the quality of the longitudinal weld. The OTK inspector pushes the tube on revolving rollers which rise just above the level of the table (there is no difficulty in throwing the tubes off into the receivers).

At the plant with the automatic tube mill, the plant personnel is employed on sorting the tubes into the receivers. The operation which takes most time is the measurement of the thickness and diameter of the tube, and the inspector has to hold the measuring instrument in his hand all the time; therefore, if he had to switch over to throwing off a defective tube the continuity of the process would be interrupted.

At the continuous-welding tube plant, the operation which takes the longest time during the inspection of tubes for export is the inspection of the surface; the inspector seldom uses measuring instruments and, therefore, the OTK workers themselves sort the tubes into the receivers, in spite of the fact that a considerable amount of tubes have to be removed from the line during the inspection.

With regard to preventing a mix-up of different steel grades, we consider that in all cases where a mix-up of steel grade may affect the service of finished products the responsibility should be left to only one man or one department at the works.

At the Cheliabinsk Tube Works, all operations connected with the check of the grade of steel are carried out by the OTK. At the steelmaking plant, the OTK workers mark the ingots with the number of the heat and the steel grade. In the metallurgical departments of the tube-roolling plants, they fill in the record sheets of metal charging and metal delivery from the reheating furnaces, and mark the billets and the tubes. The same workers check how metal of the same grades is distributed in the furnaces and check the charging operations. Only in the electric tube welding plant is the marking of billets done by women who are on the staff of the plant. It should be noted that the transfer of the billet-marking operation to the plant personnel results in a reduction of the OTK personnel but not in a cut in manpower. When work is organized in that way more time is lost than with the markers on the OTK staff. A correct decision on this problem was taken by the NTMK (Nishne-Tagil Metallurgical Combine) (Metallurgist No. 3, 1958, page 33;C.B. pagination 141), where the duties on the distribution of grades and heats, the alternation of lettered and unlettered blooms, etc. are allotted to an OTK worker. At the "Zaporozhstal" Works, the work is organized in the same way (Metallurgist No. 3, 1958).

At large metallurgical works, hundreds and thousands of railroad cars of metal products are loaded every day, and a large number of workers are engaged on filling in technical certificates. Thus, at the Cheliabinsk Tube Works,8 workers are engaged on these duties and use forms with standard data printed on them. With the object of reducing the amount of work, it should be stipulated in GOST 7566-55 and other specifications that the data on the chemical composition and results of mechanical tests are entered on the technical certificate, if required by the customer, but the steel grade is to be entered on every certificate.

In addition, it is necessary to leave out from GOST 7566-55, 4015-52 and other specifications the requirement of showing in technical certificates the data which do not refer to the quality of production, e.g. weight, length, etc, since these data are given in other documents. It is quite impossible for the OTK to check, during loading, if the weight has been determined correctly. From GOST 7566-55, the requirement of showing in the certificates "the name of the customer", and of stating that the certificate guarantees the products to satisfy standards specifications, should be left out.

The problem of enlarging the OTK sections should be approached on the principle that the amalgamation of sections is desirable only to the extent that the head of the section can still pay serious attention to details. At our Works, the sections of tube inspection at the automatic mill of the tube-rolling plant and at the 10-60 mill of the bed-tube plant have been amalgamated into one section.

CONFERENCE ON THE ORGANIZATION OF METALLURGICAL FURNACE REPAIRS AND THE PROTECTION OF LABOR

Cand. Tech. Sci. D. A. Smoliarenko, Chairman of the Org. Comm. for Convening and Conducting the Conference

In August, 1958, a Scientific and Technical Conference on the Organization of Metallurgical Furnace Repairs and the Protection of Labor was held in Stalino. About 500 representatives of 120 various organizations, National Economic Councils, metallurgical works, trade unions, medical establishments, scientific research and design institutes – took part in the Conference, among them engineers, foremen, workers and doctors. 150 people spoke during the plenary and sectional meetings.

The repair of metallurgical furnaces constitutes an involved combination of erection and constructional operations which have to be done in the shortest possible time by carrying out assembling, welding and bricklaying operations simultaneously.

In recent years, substantial improvements have been introduced into the technology of open-hearth furnace repairs; the organization of repair operations has been radically changed and basic refractories have begun to be extensively employed. Reducing the time of repairs and increasing the durability of furnaces made it possible to cut down the idle time on cold repairs to 2- 2.5% at leading works, and to reduce the total idle time of open-hearth furnaces to 5-7%.

With the object of reducing the time of repairs, several iron and steel works introduced a new system of organization, preparation and carrying out of rapid repairs to open-hearth furnaces; the characteristic feature of the system is an extensive use of the method of assembling steel structures and equipment in large units, a maximum mechanization of operations and the multistage and parallel carrying out of assembling and bricklaying operations. The technology of rapid repairs has been developed.

So far, however, the design and research institutes have not developed a single machine to mechanize the demolition work during the repairs. It is necessary to devise a compact and powerful electrically driven tractor specially fitted for repair operations. The attempt of the KMK (Kuznetsk Metallurgical Combine) to use an S-153 coal-loading machine for removing brick and slag from regenerators and for loading debris and brick chips, should be seriously considered.

It should be mentioned that for removing debris and for scraping out the rubbish and slag there are machines in use which, in the main, eliminate manual labor, but the operations on the removal of checkers and debris from under the checkers still remain arduous and nonmechanized.

In the design of open-hearth plants, the problem of furnace repairs is not taken into account: no provision is made for the storage of refractories and for the installation of stationary mechanical devices, and the passages at the valve-changing equipment at newly built open-hearth furnaces are made rather narrow. An example of such a design is the open-hearth furnace built at the NTMK (Nizhne-Tagil Metallurgical Combine) in 1957. To change the air valve, one has to dismantle the flue valve even it does not require changing.

Dinas refractories, as materials for roof brickwork, are loosing their importance in the Soviet Union, because their durability in the furnace roofs is lower than that of basic roofs. Since there is a shortage of basic refractories, the use of unfired chrome-magnesite bricks, which can be recommended for the roofs of open-hearth furnaces of up to 100-ton capacity as shown by the practice of Urals and Leningrad Works, is of definite interest.

The Cheliabinsk National Economic Council should develop the production of chrome-magnesite products extensively in order to provide conditions for changing all Soviet open-hearth furnaces to basic roofs in 1959. At the same time, the production of high-density chrome-magnesite (periclasospinelide) products should be increased.

In contradistinction to ordinary chrome-magnesite brick, periclasospinelide brick is made by grinding chromite and magnesite powder simultaneously in a turbo-mill to a fine fraction (particle size 0.06-0 mm) and subsequently compressing it slowly under hydraulic presses.

Records of the service of the roofs at large furnaces at the NTMK showed that the service life of the roof made of periclasospinelide brick (at furnaces operated with the use of oxygen) is 16% longer than chrome-magnesite roofs. The periclasospinelide brickwork of the roof is eroded more uniformly; the erosion of this brickwork in one heat was 1.5 times less than that of chrome-magnesite brickwork.

The amount of periclasospinelide brick manufactured at present by the "Magnezit" Works (5000-6000 tons per year) is quite inadequate for achieving a substantial reduction in the consumption of refractories and an increase in the length of the furnace service between repairs.

Members of the Conference have noted that the resolutions of the All-Union conferences of steel melters on the development of special-shape bricks, which would facilitate erection and contribute to improved construction of the main roof of the furnace, have not been carried out. This development work should have been done by the Stal'proekt, Giprostal' and VNIIO as far back as 1957. The Institutes of Refractories developed neither the refractory lutes, not the methods of their application onto exposed metal surfaces of parts of metallurgical furnaces and did not establish the composition of solutions and powders for various structural elements and various forms of refractory brickwork.

In the evaluation of the economics of the introduction of new constructional elements and high-durability refractories, an important factor is the time lost on current repairs and on the maintenance of the main equipment.

The analysis of losses on current repairs at steelmaking plants showed that iron and steel works have very great potential reserves of output increase and the exposure and utilization of these reserves constitutes one of the most important tasks. According to the results of operations for the first half of 1958, the losses on current repairs are still very large. Thus, the losses per ton of steel at various works were, in rubles and kopecks:

	Total	On refractory brickwork repairs
Magnitogorsk Metallurgical combine	17.15	8.75
Kuznetsk Met. Combine	21.32	11.40
Nizhne-Tagil Met. Combine	24.01	10.35
Petrovskii Works:		
Open-hearth plant	32.26	17.44
Bessemer plant	35.11	21.75
Krivoi Rog Works		
Bessemer plant	55.07	37.27

The Scientific and Technical Conference was preceded by extensive preparatory organization and scientific work. All those who attended the Conference received the preprints of the papers in advance and this made it possible to discuss thoroughly and in a businesslike manner the problems of metallurgical furnace repairs and the development of new measures aimed at an improvement in working conditions.

With the object of combining and coordinating the activities of various scientific and design organizations engaged on the normalization of working conditions at hot-operating plants of the iron and steel industry, the Presidium of the Academy of Sciences, USSR, in response to a petition by the Central Committee of the Trade Union of Workers of the Metallurgical Industry, passed a resolution on setting up a permanent commission of the Acad. of Sci., USSR, for the normalization of working conditions at hot-operated plants of the iron and steel industry. Academician I. P. Bardin, Vice-President of the Academy of Sciences, USSR, has been appointed Chairman of the Commission.

The Scientific and Technical Conference on the Organization of Metallurgical Furnace Repairs and the Protection of Labor was held in Stalino, a big industrial, iron and steel center, and, hence, the members of the Conference had the opportunity to acquaint themselves with the practices and technical achievements of the Stalino, Makeevka and "Azovstal" Works.

As the Scientific and Technical Conference was organized jointly by the Central Committee of the Trade Union of Workers of the Metallurgical Industry and Scientific and Technical Society of the Iron and Steel Industry, it was possible to invite a very wide circle of workers and specialists to discuss the basic problems of metallurgical furnace repairs and labor protection.

The recommendations, which were worked out and approved by the Scientific and Technical Conference, determine the direction of a future development of an improvement in furnace repairs. A thorough completion of these recommendations by industrial establishments and scientific and design institutes will enable them to raise their technical level substantially and to attain a further increase in steel output.

RESULTS OF THE STEELMAKING COMPETITION ORGANIZED BY NTO ChM*

One of the potential sources of steel output increase and steel-cost reduction is the extension of the campaign of the open-hearth furnace at a high output of the furnace. In connection with the increase in the length of the campaign, in particular for furnaces with chrome-magnesite roofs, the durability of slag pockets and checkers falls and, therefore, the advantages of basic roofs of open-hearth furnaces are not fully utilized. The capacity of the slag pockets becomes inadequate for the slag formed in the course of the campaign, so that the furnaces have to be shut down for the cleaning of the slag pockets and, hence, the furnace output is affected. Therefore, the problem of either the continuous or the periodic removal of slag from the slag pockets while the furnace is in operation acquires specially great importance.

The introduction of chrome-magnesite roofs was conducive to an increase in the temperature of flue gases leaving the working space of the furnace and that had a negative effect on the conditions of the thermal operation of the checkers; with the result of a reduction in the life of the checkers. A disparity between the enhanced durability of the furnace proper and the inadequate durability of the checkers became apparent.

Slag pockets and checkers at present constitute the "bottlenecks" in the operation of the open-hearth furnace. Therefore, a great number of innovators and inventors are working on the problem of mechanizing the removal of slag and the cleaning of checkers in the course of furnace operation.

In 1957, the Scientific and Technical Society of the Iron and Steel Industry announced a competition on "The Development of New Methods of Slag Removal from the Slag Pockets of the Open-Hearth Furnace" and on "The Development of Methods of Cleaning the Regenerator Checkers of the Open Hearth Furnace".

Eighteen projects relating to "The Development of New Methods of Slag Removal from the Slag Pockets of the Open-Hearth Furnace" and 10 projects relating to "The Development of Method of Cleaning the Regenerator Checkers of the Open-Hearth Furnace" were submitted.

The projects on slag removal fall into two groups. The first group comprises the projects which involve mechanical methods of removing slag in solid state, and the second – the projects which involve the removal of slag in liquid state. Various methods of slag removal are considered in the projects: removal en bloc, by means of a rope filled in the tubes on bottom of the slag pocket and protected by false walls, removal by means of transportable metallic boxes and containers lined with refractory bricks, and removal by means of scraping conveyers and by other raking mechanisms.

The project called "Ural" (the authors: I.I.Lesunov, B.P.Tishchenko, B.E.Pis'mernikov and V.A.Shalagin, on the staff of the repair shop of the furnaces at the Nizhne-Tagil Metallurgical Combine) gives a satisfactory solution to the problem of slag removal by using a tractor equipped with a special hinged attachment. This method of slag removal makes it possible to reduce the stoppage time of furnaces during cold and hot repairs*. The projects on the removal of slag in liquid state envisage the installation of special tapping holes for draining the slag from the slag pockets. Prior to the drainage of the slag, the temperature in the slag pockets is raised by means of burners, and liquid slag is tapped into a slag pot. It is proposed to introduce a special mixture into the slag pocket at regular intervals to keep the slag in liquid state. Several methods are proposed for the cleaning of checkers of dust and the removal of dust from under the checkers.

Some projects envisage the construction of checkers on the model of Cowper stoves, which are less liable to dust accumulation. The upper 10-12 rows of a checker of Cowper stove type are laid with forsterite brick. The author of one project proposes that the checker bricks be coated with a special solution of chrome-magnesite powder with the object of improving the refractory properties of the brick. It is proposed that the checkers be cleaned of dust by means of a series of consecutive blastings, spaced over the height of the checker: by means of high frequency b vibrators with flexible hose, or by means of blowing compressed air and water. Several authors propose the removal of the settled dust from the space under the checkers of the regenerator by means of water, vacuum pumps and other methods.

*Scientific and Technical Society of Iron and Steel Industry.

The shortcoming of the majority of the projects is that they do not contain enough design data. Nevertheless, the competitition showed that the personnel of metallurgical establishments do active work on the mechanization of very difficult and important sections of the open-hearth furnace plant.

Prominent experts from industrial establishments and design organizations were invited to evaluate the proposals submitted.

After considering the results of the open competition, the Scientific and Technical Society of the Iron and Steel Industry confirmed the decision of the jury in awarding a 7500 Rubles prize for the project "Ural" and two consolation prizes of 1000 Rubles each for the projects "Mechanization of dust removal from under the checkers and flues of open-hearth furnaces by means of a vacuum conveyer" and "Blow-out of checkers with compressed air and water by means of a flexible hose." The projects which won the consolation prizes cannot be utilized in full, but they contain separate elements which can be commended for future development work on the mechanization of operations of dust removal from regenerators.

Open competitions on important problems of the steelmaking industry are conducive to more activity on the part of inventors and innovators in their work on solving difficult problems in the mechanization of steelmaking processes.

N. I. Efanov
Chairman of the Competition Jury.

•Detailed description of the practice of slag removal from the slag pockets at the NTMK was given in Metallurgist No. 12, 1957.

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During the next year, progress in the fulfillment of the great tasks set out by the Party and the Government in the current seven-year plan will be extensively reviewed, and reports will be given on the development of new iron and steel centers and on the construction of new machinery. Considerably more space will be allotted to information on the new techniques of foreign metallurgists.

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